Commentary on the Management of Fish Habitat in Northern Canada: Information Requirements and Policy Considerations Regarding Diamond, Oil Sands and Placer Mining – Appendix

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COMMENTARY ON THE MANAGEMENT OF FISH HABITAT IN NORTHERN CANADA: INFORMATION REQUIREMENTS AND POLICY CONSIDERATIONS REGARDING DIAMOND, OIL SANDS AND PLACER MINING – APPENDIX

by

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PREFACE

This document is the Appendix to a technical report (Birtwell et al. 2005*a*) that has been prepared in response to the need for information that will assist the management of fish and their habitat in northern Canada, and especially that relating to exploration and mining for diamonds. Increased exploration and mining activity is occurring across Canada and potential diamond mines have been identified in Nunavut, Alberta, Saskatchewan, Ontario and Quebec. Diamond mining is currently occurring in the Northwest Territories.

Fisheries and Oceans Canada (DFO) has authorized the elimination or partial destruction of 26 lakes for diamond mining since 1997, and an additional 5 for the metal mining sector. The elimination of lakes is escalating in relation to the needs of the mining sector in Canada.

The application of appropriate compensatory and restorative techniques is a fundamental requirement of developments that impact fish and their habitat. This poses an especially significant and unique challenge in northern Canada because of the prevalent climatic conditions and the paucity of applicable knowledge.

Although the focus of the technical report was related to diamond mining in the Arctic, attention was also given to oil sands and placer gold mining; other major industrial activities in northern Canada that impact upon fish and their habitat. In addition, information was provided on the elimination and degradation of lakes across Canada for metal mine tailings disposal and access to ore as well as the associated compensatory and restorative measures for damage to fish habitat.

One of the main objectives of the technical report was to identify deficiencies in knowledge with respect to fish and their habitat in northern Canada, and the implications of habitat alteration and destruction to aquatic systems. Comments were also provided on related habitat compensatory and restorative measures and the consistency of application of the *Fisheries Act* and use of the "Policy for the Management of Fish Habitat" (Department of Fisheries and Oceans 1986).

Fifty-one representatives of the diamond, placer gold, and oil sands mining industries, scientific and operational colleagues in governments and academia, and certain independent people collaborated in the production of this report by providing valuable information and insight. Original, unabridged, and condensed comments from these consultations are contained in this document which, together with 3 other reports (Birtwell et al. 2005*a*, 2005*b*; Khan et al. 2005), detail the study components, the conclusions and recommendations.

Specific details regarding the elimination and degradation of fish habitat for mining in Canada, and associated compensation and restoration are also reported, as are details of recent scientific research carried out by DFO staff in relation to placer mining.

It is apparent that there is still much to know about the biology of Canada's north, the implications of climate and habitat change to aquatic organisms, and the appropriateness and adequacy of compensation and restoration, and development activities. It is hoped that the information within this report will draw attention to some of these deficiencies in our understanding of the ecology of certain aquatic organisms and thereby help guide scientific research and assist habitat management.

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ABSTRACT

Samis, S.C., Birtwell, I.K., and Khan N.Y. 2005. Commentary on the management of fish habitat in northern Canada: information requirements and policy considerations regarding diamond, oil sands and placer mining – Appendix. Can. Tech. Rep. Fish. Aquat. Sci. 2608: xii + 196 p.

This report is the Appendix to a detailed technical report (Birtwell et al. 2005) which identifies scientific and management information needs that are necessary in order to make consistent and defensible decisions which conform with the intent of the "Policy for the Management of Fish Habitat" (Department of Fisheries and Oceans 1986), and that enable responsible mining activities compliant with the *Fisheries Act* (Government of Canada 1985). Increasing mining activities in Canada and the associated need to eliminate and degrade lakes and watercourses provided the stimulus for the assessment. Since the 1950s, 50 lakes, in whole or part, have been eliminated or approved for elimination. Of these lakes, 62% (31) were in the last decade, and an additional 20 are to be considered for approval in the next 4 years.

Compensation for the destruction of lakes and streams and their restoration pose significant scientific and management challenges, especially in northern Canada where ecological knowledge and understanding are rudimentary.

This report contains details of the elimination and degradation of fish habitat that has occurred in lakes and streams in Canada since the 1950s to enable mining to progress, together with associated compensatory and restorative measures. Details of recent scientific research carried out by DFO in relation to placer mining are also included.

The original unabridged, and condensed comments and opinions from diamond, placer gold and oil sands mining representatives, government scientists and habitat practitioners, and other knowledgeable people in private and public sectors are presented in this report. These comments provide an insight into current habitat management practices and policies, industrial development, and related scientific research and needs.

Assessments of published literature on the biology of selected Arctic species of fish and watershed ecology were amalgamated with this information thereby providing the basis for conclusions and recommendations regarding the management of fish habitat, and the scientific information and procedural requirements to effectively fulfill Departmental responsibilities in this regard (Birtwell et al. 2005*a*, 2005*b*; Khan et al. 2005).

RÉSUMÉ

Samis, S.C., Birtwell, I.K., and Khan, N.Y. 2005. Commentary on the management of fish habitat in northern Canada: information requirements and policy considerations regarding diamond, oil sands and placer mining – Appendix. Can. Tech. Rep. Fish. Aquat. Sci. 2608: xii + 196 p.

Le présent rapport est l'annexe d'un rapport technique détaillé (Birtwell et al. 2005) qui présente les renseignements scientifiques et l'information de gestion requis pour permettre la prise de décisions cohérentes et défendables, conformes à l'esprit de la Politique de gestion de l'habitat du poisson (Ministère des Pêches et des Océans 1986), et qui contribuent à faciliter des activités minières responsable conformes à la *Loi sur les pêches* (Gouvernement du Canada 1985). Les activités minières à la hausse au Canada et le besoin résultant de détruire et de dégrader des lacs et des cours d'eau sont à l'origine de la présente évaluation. Depuis les années 1950, 50 lacs, en entier ou en partie, ont été détruits ou leur destruction a été approuvée. De ceux-ci, 62 % (31) l'ont été au cours de la dernière décennie, et l'approbation de la destruction de 20 autres sera considérée au cours des quatre prochaines années.

La compensation de la destruction et la restauration de parcelles d'habitat lacustres et lotiques posent d'importants défis sur le plan scientifique et gestionnel, en particulier dans le nord du Canada, car les connaissances et la compréhension de l'écologie de cette région sont plutôt rudimentaires.

Ce rapport contient des précisions concernant les cas de destruction et de détérioration de l'habitat du poisson survenus dans des lacs et des cours d'eau au Canada depuis les années 1950 afin de permettre la progression des activités minières. Sont également présentées les mesures de compensation et de restauration prises. Des précisions sont également offertes au sujet des travaux de recherche récemment effectués par le MPO en rapport avec l'exploitation de placers.

Les versions originales non abrégées et les versions abrégées des commentaires et opinions de représentants de mines de diamants, d'or placérien et de sable pétrolière, de scientifiques de l'État et d'agents responsables de l'habitat, ainsi que d'autres personnes bien informées des secteurs public et privé, sont présentées dans ce rapport. Ces commentaires donnent un aperçu des pratiques et politiques actuelles en matière de gestion de l'habitat du poisson, du développement industriel et des recherches et besoins connexes sur le plan scientifique.

Les résultats des analyses des ouvrages scientifiques sur la biologie de certaines espèces de poissons de l'Arctique et l'écologie des bassins versants ont été combinés aux commentaires et opinions reçus afin d'établir le fondement des conclusions et des recommandations concernant la gestion de l'habitat du poisson, ainsi que les renseignements scientifiques et les modalités d'application pour s'acquitter efficacement des responsabilités du Ministère dans ce sens (Birtwell et al. 2005*a* et 2005*b*; Khan et al. 2005).

INTRODUCTION

This report is a supportive document to others (Birtwell et al. 2005*a*, 2005*b*; Khan et al. 2005) that address the need for information and its application for habitat management in northern Canada. Increasing mining activities and the associated need to eliminate and degrade lakes and watercourses provided the stimulus for the assessment. Since the 1950s, 50 lakes, in whole or part, have been eliminated or approved for elimination, of which 62% (31) were in the last decade, and an additional 20 are expected to be submitted for consideration in the next 4 years.

Compensation and restoration for lake and stream destruction pose significant scientific and management challenges, especially so in northern Canada where ecological knowledge and understanding are rudimentary. This report contains details of the elimination and degradation of fish habitat that have occurred in Canada to enable mining to progress, together with associated compensatory and restorative measures.

Assessments of published literature on the biology of selected Arctic species of fish and watershed ecology have been combined with opinions from diamond, placer gold and oil sands mining representatives, government scientists and habitat practitioners, and other knowledgeable people in private and public sectors (Birtwell et al. 2005*a*, 2005*b*). The amalgamation of opinions and published information provided the basis for drawing conclusions and making recommendations regarding the management of fish habitat, and the scientific information and procedural requirements to effectively fulfill Departmental responsibilities in this regard.

This report contains the complete, and condensed and categorized, comments of those consulted during this review, details of lake elimination, tailings impoundment areas (TIAs), and their regulation, and recent research by DFO related to placer mining in the Yukon.

CONSULTATIONS

Fifty-one people voluntarily contributed to this report through the direct submission of comments and via interviews. Their name, affiliation, and accepted interview comments are presented in this report.

DIAMOND, PLACER GOLD, AND OIL SANDS MINING INDUSTRIES

Four questions were posed to industrial representatives:

- What are the priority research/information needs regarding diamond mining/placer mining/oil sands development (as appropriate to the specific industry) and aquatic systems?
- What are your opinions regarding collaboration with DFO/universities/other industries?

- Regarding compensation/restoration actions, who decided upon that which was appropriate, who assesses the success/failure of them and what are the measures of success?
- What are the limitations to the growth of the industry, and what is the forecast for the future?

Respondents to these questions were identified by mining sector affiliation as follows: Allison Armstrong, Jane M. Howe, Jayda Robillard, Gord Macdonald, and Robin Johnstone (diamonds); Calvin Duane, Chris Fordham, and Darrell Martindale (oil sands); Mike McDougal and Tara Christie (placer gold).

HABITAT PRACTITIONERS AND MANAGERS

Consultation with this group was considered necessary because of its interface with industry and the need for information to assist with the decisions that must be made regarding fish habitat and developments.

Nine questions were asked in relation to oil sands, placer, and diamond mining, and other industrial operations that have the potential to affect fish habitat (e.g. use of lakes as tailings impoundment areas for metal mining). Representatives from all DFO Regions across Canada were canvassed for their input.

- Is there a formal or informal decision making process whereby habitat managers are able to assess impacts on fish and their habitat? Depending on the answer…what is it or how is it done?
- How are fish and fish habitat loss dealt with in quantitative terms? What are the species/habitats of concern?
- How are cumulative impacts addressed? Is there concern at the fish population level, the lake and/or watershed level?
- What knowledge gaps exist and how is this dealt with in decision making?
- How is uncertainty incorporated into the decision-making process regarding compensation?
- How is habitat restored in northern locations such as the Yukon, Alberta, Northwest Territories, and Nunavut – as appropriate re industry? What are the pros and cons? Are there case studies (successes and failures)?
- What initiatives (and who is doing them) are underway to fill gaps in knowledge and improve decision making over damage to fish and their habitat?
- What initiatives (and who is doing them) are underway to examine fish habitat compensation and restoration activities?
- Is collaboration with industry on monitoring/research ventures mutually profitable, and are there opportunities to further such co-operation?

Respondents to these questions are identified by DFO Region, as follows: Jeff Johansen and Al von Finster (Pacific Region); Julie Dahl, Jennifer Shamess, Dorthy Majewski, Alan Merkowsky, Derrick Moggy, Tania Gordanier, Ed DeBruyn, and Rich Rudolph

(Central and Arctic Region); Sophie Bérubé (Quebec Region); Carole C.J. Grant and Mary B. Dawe (Newfoundland Region).

HABITAT SCIENCE AND NORTHERN ECOLOGY

Discussion with other people focused on selected topics about which they are particularly knowledgeable (Lionel Johnson, Terry Dick, Gordon Hartman, Peter McCart, David Fernet, John Gulley, and François Landry regarding Arctic ecology, Karsten Liber regarding toxicology, Mike Miles regarding geomorphology, Don Toews regarding fish ecology, and DFO scientists and engineers (Colin Levings, Mike Bradford, Martin Bergmann, Susan Doka, Rick Gervais, Chris Katopodis, Marten Koops, Ken Mills, Ken Minns, Michael Papst, Bob Randall, Terence Shortt, Michael A. Turner, and Mike Whittle) regarding fisheries management, ecology, habitat linkages, measurement and validation, and André Isabelle (Natural Sciences and Engineering Research Council of Canada, NSERC) regarding research funds, David Harper and Jason Quigley regarding habitat compensation and assessment, and Paula Pacholek regarding the coordination of northern environmental assessment.

PRESENTATION OF COMMENTS AND SCIENTIFIC FINDINGS

The extensive and valuable comments received through these consultations were condensed and placed into the categories of a) Research, b) Mitigation, Compensation and Restoration, and c) Policy and Management. The significant main points were separated within each category as "Selected Points" and "Recommendations." The same approach was used to abstract information from the scientific literature that we had gathered. Thus there were two sets of information bases – scientific and consultative.

The comments from the consultations were used as a starting point from which the next phase of the assessment occurred. Common topics from the consultations were searched for within the scientific information base and then combined with those from other consultations to provide un-ranked key topics. As an audit function the origin of the information used in this step was identified and linked to its source (scientific literature or consultations). Thus the final key topics are those that were identified through the consultations and that were also present in the scientific literature we abstracted for this task. Through this amalgamation it was expected that more value and importance would accrue to the final deduction of key issues. This process included inherent biases as, for example, some of the literature that was assessed was authored by some of the people who were consulted. Similarly, there was the expectation and likelihood that those with whom we consulted also knew some of the relevant scientific literature.

The final key topic areas deduced via the above-mentioned process represent statements and recommendations that are an amalgamation of comments from scientists, habitat management practitioners, industrial representatives, academia, and other people with an interest in, and knowledge of, the management of Canadian aquatic resources, together with findings and deductions from published scientific literature. They are presented in the reports by Birtwell et al. (2005*a*, 2005*b*).

COMMENTS RECEIVED

A number of interviews were initiated to obtain the opinion of knowledgeable people involved with the management and science of fish and their habitat, and industrial operations with the potential to impact them. Written and verbal comments are included in this section with the agreement of those who supplied them.

Answers to the questions posed to representatives of industries and habitat managers and practitioners across the country, together with comments on selected topics were obtained by teleconferences and e-mail and from meetings. Italicized comments are examples provided by those consulted.

Industry

Diamond mining industry:

BHP Billiton – Ekati Mine

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1. What are the priority research/information needs regarding diamond mining and aquatic systems?

- There will be more diversion channels required in relation to diamond mining and for fish habitat compensation.

- We need to improve our understanding of the use of un-impacted streams by fish species so that we can assess diversion channels. If we had good baseline biological information on northern streams we could compare it with data obtained from the monitoring of diversion channels. *For example, with the Panda Diversion Channel.* It would be good to compare our results with un-impacted streams.

- One area of research that could be focused on by the government is studying the ecology of un-impacted streams in the north.

- *BHP Billiton (Ekati) started to look at the ecology of other streams this year for comparison with the Panda Diversion Channel (PDC).* It would be useful to have comparative information on other streams in the area that would allow an assessment as to whether the PDC compensation is working.

- Research should also be conducted on "untouched" lakes. Both streams and lakes, however, have equal value from a research perspective.

- We believe research is important. Most of the work that has been carried out in relation to the Ekati mine has been more monitoring than research. We are constantly tasked with preparing habitat compensation plans using models based on southern species and southern habitats. We are interested in changing how we collect information and perhaps moving toward more of a research style in order to better defend our hypotheses and predictions. Industry plays a role in research, but research is not the mandate of industry, and research would not meet our regulatory/compliance obligations.

- The environmental monitoring programs commenced without the benefit of northern models for use. But there were no other models to work with. This is where research could play an important role. We need research – if we do not understand how northern species use lakes and streams, we cannot answer fundamental questions. One danger of not understanding the ecology is that monitoring is conducted for the sake of monitoring without a proper understanding of what is being collected or why.

- In 2003 the PDC monitoring program was enhanced to begin to fully address the outstanding question as to whether the measures taken have been successful in maintaining the productivity of fish habitat proving productivity. BHP Billiton worked cooperatively with DFO to address outstanding issues and to enhance the monitoring program.

- A missing link in a lot of data collection is the analysis. In our Aquatic Environment Monitoring Program (AEMP), for example, we analyzed all data available since 1994 and statistical analyses were conducted to identify any potential changes. When government agencies develop monitoring criteria, they should be prepared to take the data to another level, and put it against the hypotheses and conclusions drawn. Such data should be valued and used to make decisions. We often hear the criticism: why can you not tell us what is happening at the diamond mines?

- Too often we are required to conduct programs based on southern models without knowing if these models are applicable to the north. Without the government analyzing the data, we do not know if the models are applicable and could potentially conduct years of programs, studies and data collection using inapplicable models.

BHP Billiton's consultants have compiled data from baseline and fish-out programs and this is being analyzed to create a predictive model for future use by researchers at the University of Alberta. This is the only example of how our data have been used.

2. **What are your opinions regarding collaboration with DFO/universities/other industries?**

- Projects should be conducted jointly with government, as is the fish-out work mentioned above. The company collects the data, it gets interpreted, and DFO, given its mandate for no net loss (or to confirm that, as part of the monitoring program, its decision processes are working), needs to manage the research.

- Regulators should be more involved in collaborative approaches. Because regulators require data to be collected, they are almost obligated to be involved in the assessment of that data. The fish-out study is an example and is the first time that we have seen collaborative studies with the regulator – this is long overdue. However, industry is required to follow a protocol to conduct lake fish outs, but no one has assessed the protocol, and now we are nearly finished. The opportunity was lost to assess whether the methodologies were appropriate in a timely manner so that the next fish-out program protocol could be adapted and/or improved.

- When we (Rescan) started to work at Ekati we saw immense research opportunities. There is so much monitoring data being generated, but the data are analyzed to look at effects and not at the ecology of the systems. There are still amazing possibilities for joint research.

- We, in industry, are fully willing, keen in fact, to cooperate, and would like to see the information we have generated used in making recommendations for developing adaptive management strategies that are relevant to our operations. The only note of caution is where the monitoring is legally required for regulatory compliance. In this instance industry has to do this itself, with its own quality control and timing.

- Studies need to be of benefit to companies for industrial collaboration to occur, for example, understanding the ecology of lake trout from the local environment.

- Ekati has started a little of this with the fish-out study analyses, and we see more with the Panda Diversion Channel study. But overall the industry is not organized into any group that would assist in the design and planning of research. If there was such a cooperative group, we could meet once or twice a year and, it could be very useful.

- We have approached DFO in the past to provide advice and input. *For example, we get a fish habitat authorization and we are required to develop terms of reference for compensation with DFO. The feedback we receive is often vague.* We try to develop plans, studies and programs without clear direction from DFO. We think that the link between DFO Habitat Management and Science in the north may be missing. We develop our plans, studies and programs with the best intentions, but without clear direction from DFO, or a collaborative approach in the development of the terms of reference. We are not mind readers. Even when we submit the terms of reference to DFO we do not always collaborate in the formation of them and we get critical comments from DFO. A better approach would be to work together in the development of the terms of reference for plans, studies and programs and to have clear direction and definitions of what the targets/goals are.

- We think that the science component is missing in the Arctic at DFO. As the writers of reports we would like to do a good job. *For example, in monitoring the Panda Diversion Channel, if DFO Science could be more involved in helping to design and commenting on the proposals, then we would know if we were taking the correct approach.* However, we do not want to alienate the local DFO office. In the past, we have developed monitoring plans and undertaken work, which costs a lot of money, only to find out that it does not meet DFO's requirements after two years of data collection. We believe that this occurred because the expectations and end goals were not clearly communicated.

3. **Regarding compensation/restoration actions, who decided upon that which was appropriate, who assesses the success/failure of them and what are the measures of success?**

- Even though we design compensation plans, it is DFO that decides on what is appropriate for compensation. *For example, the 2:1 compensation ratio, and like-for-like to achieve no net loss – we have to achieve this. The Panda Diversion Channel is the only existing compensation work we have. The Nero-Nema Bridge is next, but the plan is not fully developed.* In the past there was very little input from DFO regarding the content of compensation plans, but this is changing and we are working more cooperatively these days.

- Industry needs clear guidelines on assessing the success or failure of compensation. *At the Panda Diversion Channel we have not been able to determine whether the measures taken have been successful in maintaining the productivity of fish habitat because the end goal is a moving target.* The company is not sure when success or failure will be accepted by DFO. There is a lack of guidance and standardization.

- We provided a set of endpoints that we felt were appropriate to measure the success of the PDC to DFO (e.g. annual production in terms of numbers of spawners, and grams of fry per m^2, egg survival, fry density, etc.) in comparison with two reference streams. We are very interested in hearing DFO's comments, but at this time, we are almost ready to start the 2004 monitoring program with no comments from DFO. We are excited about this investigation of the PDC, and others have said that it is a great piece of work. However, DFO has not yet provided comments.

4. What are the limitations to the growth of the industry, and what is the forecast for the future?

- There has been staking of huge tracts of land throughout Canada; this is the typical nature of exploration for minerals. It is extremely speculative and large areas must be evaluated and ultimately very small areas are focused upon. Mining and prospecting associations have done analyses of how much of an area must be explored on average to get one viable mine. Concerns about huge industry growth are unfounded for diamond mining. The Ekati claim block (70 by 30 km) contains 200 kimberlite pipes, most of which have been fully assessed but have no diamonds; a few have diamonds but are not economic to extract. Seven or 8 of the 200 pipes are all that are worthy of consideration. Some of these are marginal at best, and without the infrastructure in place, a few of these pipes would not be mined. Major economic hurdles exist for a pipe to be mined and changing international fiscal conditions can easily alter the economics of a marginal pipe.

- In order for exploration to occur, industry needs the ability to assess large blocks of land efficiently without onerous permitting. We need land use permits, and must do business correctly, clean up, and not cause impacts. Exploration has negligible, if any, lasting impacts or footprint.

- Exploration for diamond mining in Canada has been hampered or delayed due to concerns over potential impacts. For example, drilling through ice is considered to have the potential to impact fish habitat, but it is extremely minor (one square foot where the drill penetrates the lake bottom, plus the secondary impacts of siltation within a very limited radius from the hole). DFO keeps raising these concerns about sediment, so could DFO quantify its concerns and confirm them? If there is an impact, what needs to be done?

- Environment Canada has done studies on drilling through ice and has indicated there is no concern – it puzzles us why DFO is still concerned. Diamond exploration companies trying to explore have had to prove drilling does not have any impact on fish habitat, before DFO will allow the work. But exploration drilling through lake ice has been going on throughout Canada for many decades; it has never been an issue before. Information that has been relayed by some companies to DFO was not deemed to be adequate, beyond a shadow of doubt. Again, this is another example of how it is unclear what DFO expectations are.

- Several companies have had to defer drilling projects for one year as a result of these concerns. This hampers exploration. It seems impractical that every exploration company should have to prove there won't be any impact from a "common activity" such as drilling. It would be helpful if DFO could contribute to this.

- *A lot of work has been done on gas exploration under ice in the Mackenzie River delta in winter.* The results of this work could be used to assess the impacts of drilling. Reports went to DFO in Inuvik (a lack of communication?).

- We attended DFO's Pathways of Effects (POE) meetings with industry recently. We asked DFO to co-sponsor a workshop on mining to discuss development of operational statements like drilling through ice. We support the POE approach. The Risk Management Framework has merit; POE will be very useful from industry's perspective in that it is transparent, clearly identifies the decision-making framework and enables us to focus on mitigation.

De Beers Canada – Snap Lake

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1. **What are the priority research/information needs regarding diamond mining and aquatic systems?**

- Benefits from research and monitoring will be new knowledge.

- Regarding new information, we may need to collect information for a broad-based application.

- Research is needed regarding habitat compensation techniques.

- What is the end point to consider regarding impacts of development? Ecological integrity? We must examine the key parts of habitat that are available – it is a functional issue.

- Site specificity is a problem and baseline information is needed.

- On the broad scale there is a need to identify what thresholds are acceptable regarding the loss of lakes. The issue of watershed-level effects relates to the size of lakes and their number.

- Perhaps DFO should consider a risk-based Environmental Assessment approach to the elimination of an individual lake, and relate it to the magnitude and duration of the impact of mining activities. Assess whether the effects are reversible in a geographic context. What is the consequence of the losses/change at the end and what is the significance?

- Perhaps a worst-case scenario should be assessed. Include 10s to 1000s of lakes in a desktop exercise, and identify limits on a geographical scale (for this relates to significance). Basically take a coarse-level approach, and look at different levels of lake removal. The Slave Geological Province has numerous lakes but what can be lost without "effects"?

- In this regard the World Wildlife Fund (WWF) has a strategy for protected areas and has adopted an ecozone approach.

- An assessment agreement should focus on "thresholds," issues of significance, and acceptability, regarding environmental impact. Such an approach will incorporate that which is critical habitat.

- Considering a risk-based assessment (based on current information and uncertainty):
  - Identify potential environmental aspects;
  - Probability of issues;
  - Connecting risk and uncertainty; and
  - Focus on critical evaluation to identify what can be lost or impacted.

- Stella Swanson (Golder Associates, Calgary 403-299-5600) is a contact re risk assessment (human/environmental health).

2. What are your opinions regarding collaboration with DFO/universities/other industries?

- Research in the field should be focused on compensation, and De Beers is willing to undertake cooperative research in this regard.

3. Regarding compensation/restoration actions, who decided upon that which was appropriate, who assesses the success/failure of them and what are the measures of success?

- *A spawning habitat was created (reef, laid down on ice, expected 2-m profile) compensation feature.* The advisor was Peter Cott (DFO). Basically, this was an experimental approach regarding its design and placement.

- Criteria and methods are required to assess whether the spawning structure has been a success. Golder Associates have been carrying out monitoring activities. An evaluation by a fisheries biologist was that it was better than the existing natural structures.

- A second reef (for spawning) is to be placed into a lake. Julie Dahl (DFO, Yellowknife) has details of the monitoring plan.

- Opportunities exist to study this compensation activity – a coordinated approach will be necessary.

- Regarding compensation options, the improved access for fish to additional habitat is one of the better options for De Beers, increasing depth of lakes is also a consideration.

- Actions should be based on a risk approach.

4. What are the limitations to the growth of the industry, and what is the forecast for the future?

Rio Tinto-Aber, Diavik

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1. What are the priority research/information needs regarding diamond mining and aquatic systems?

- The company's Environmental Assessment scoped the fish and water quality issues regarding the Diavik mine.

- DFO had input regarding fish, the Water Board regarding water to invertebrates, and there is a "grey zone" regarding primary producers.

- Fidelity to spawning grounds is a high priority topic for some.

- Basic biology for northern species is not well understood. There is a need to identify that which is important to different life stages.

- There is also a need to focus upon quantifying the value of habitat, which then feeds into the consequences of the loss due to development.

2. What are your opinions regarding collaboration with DFO/universities/other industries?

- The collaborative approach to provision of information is workable. Leaving it as an industry-based initiative will not be optimal.

- *Diavik is already undertaking a collaborative research project with University of Alberta (Bill Tonn) regarding the impacts of blasting.* We have an NSERC project with an M.Sc. student. There has been some collaboration with DFO on this project.

- There are opportunities to do good cooperative research, but company's funds are finite.

- Environmental Advisory Board of Diavik is community based. Chair is Bob Turner. Peter McCart was an advisor regarding fisheries issues, and Dave Fernet (Golder Associates, Calgary) regarding no net loss of habitat (also worked with Ken Minns, DFO).

3. **Regarding compensation/restoration actions, who decided upon that which was appropriate, who assesses the success/failure of them and what are the measures of success?**

- The plans of Diavik regarding "no net loss" of fish habitat have been quantified through "habitat units." Uncertainty in compensation is dealt with through the provision of more "habitat units," and monitoring will reveal whether they were used.

- With respect to data gaps, there is the issue of habitat loss. "We" have weak tools to assess habitat loss, and we have followed Ken Minns' (DFO) advice in this regard. But we do not have enough information about fish in this region.

- With respect to compensation for habitat lost, there are options to improve access to fish-less lakes and for Aboriginal fishing, also to increase the depth of shallow lakes.

- Fertilization of lakes is ruled out as an option from a scientific perspective.

4. **What are the limitations to the growth of the industry, and what is the forecast for the future?**

- Regarding mining overall, society's view has the greatest effect.

- There is interest on the community side to understand the science, and with a progression towards self government there will be a need for this information and understanding.

- It is likely that there will be more Aboriginal control over time.

- Monitoring activities review – there is a technical review group under the Water Board and there is the Environmental Monitoring Advisory Board.

Placer gold mining industry:

Klondike Placer Miners' Association

Mike McDougal, President

Tara Christie, Past President, Executive Director
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1. **What are the priority research/information needs regarding placer mining and aquatic systems?**

- Priority research will likely be identified by the Implementation Steering Committee (ISC) charged with developing the new placer regulatory regime to support the new regulatory regime and to put measures in place to demonstrate no net loss (NNL), and possibly a net gain (NG) of fish habitat.

- We need to assess what works most cost effectively, and ensure that people use approaches that are most effective.

- We need to evaluate the techniques that will ensure productive streams after restoration.

2. **What are your opinions regarding collaboration with DFO/universities/other industries?**

- Research is being conducted by the Yukon Territorial Government (YTG – Don Toews) in co-operation with DFO to assess the health of streams through stream investigations which look at multiple factors: including aquatic invertebrates, quantity, diversity and life stage of fish present and types of habitat. This research has documented important attributes in placer-mined streams not previously investigated.

- It is important that we look at stream health and watershed health through monitoring. Research is limited but it is cooperative, and we continue to get co-operation from First Nations, YTG and DFO.

- We favor a cooperative approach to research projects.

- With regard to post-secondary institutions, it is important that there is sufficient guidance, resources and understanding (interaction). We have found in the last few years that university students, without clear guidance and understanding, have produced research results that are not useful as they were not properly grounded. We must ensure the research is relevant to, and develops completely, the response to the information requests.

- In the 1990s the industry supplied $250 K towards major studies on placer mining and its effects. We have had some success and some disappointment with studies we have funded (with non-DFO research). Consultants' time and miners' time was donated along with a significant economic contributions, but the information was not incorporated or considered in the development of the YPA (or properly evaluated later) and many were discouraged from participating in future "collaborative" projects by this response. Collaboration should be meaningful for all participants.

- As the new placer mining management regime is developed, independent research is required to monitor the effectiveness and achieve NNL. How change is evaluated is very important. For example, to assess the effectiveness of compensation – we need to know what the end results are. Are they healthy, productive streams? What has changed?

- There are opportunities for a net gain of habitat, and we have to take advantage of and recognize these opportunities.

- Considering time frames in which to assess success of restoration or compensation, we need short term assessments to give comfort, but cannot ignore the 5 to 10-year term and the 20-plus-year term.

- Much of the specific research on placer mining was done prior to the implementation of the Yukon Placer Authorization (YPA) in the early 1990s and the Mining Land Use Regulations (MLUR) in the late 1990s. These regulatory changes have had a positive impact on the way industry has operated since that time and effective regulatory control has been achieved (Energy, Mines and Resources, EM and R client services annual reports). Updated research to evaluate the effectiveness of these regulatory changes would be useful to inform our new regime for placer mining and for understanding the effectiveness of the application of best practices for placer mining.

3. **Regarding compensation/restoration actions, who decided upon that which was appropriate, who assesses the success/failure of them and what are the measures of success?**

- The compensation and restoration requirements were set out in the Yukon Placer Authorization "White Book" and in site-specific authorizations issued by Yukon Area DFO where compensatory channels were required.

- Inspections are performed by EM and R Mine Inspection staff under an MOU with DFO for compliance with YPA requirements.

- Evaluating success is difficult as change can be neutral, negative or positive and can be subjective. Meeting measures of success requires flexibility in the evaluation of success. Other research needs to be conducted to better deal with uncertainty.

- There is a need for holistic studies on stream health and restoration. We need to conduct research to bridge the practical aspects of industrial activities to academic research to help fulfill the regulatory information needs and to deal with the areas of limited understanding.

- We also need to understand the interrelationships of industry impacts to help us with practical aspects of understanding natural systems.

- Understanding natural variability is therefore a key. More information and collaboration is required, for example, on benthic data – natural variation within and among streams is poorly understood. It is related to natural cycles? Need temporal and spatial reference sites.

- A new Best Practices Manual is being developed and we can add to this what we have learned while operating under the restoration guidelines that are contained in the "White Book" and Mining Land Use Regulations (MLUR) best practices.

- We need to do short-term research to feed back into an "adaptive management tool" to allow for field truthing of any assumptions used in constructing the new placer regime, so industry has some assurance that they will not have future liabilities when they have used best practices and knowledge of the time.

- The current research being conducted (primarily by Yukon government biologists, with some participation by DFO regional field personnel and data support from Environment Canada), to understand the biological and physical effectiveness of our restoration practices will be useful. This work will be used to guide future research programs. Concurrently, the Yukon Government, client services, has had its inspectors and technicians conduct extensive watershed water quality investigations to augment the biological investigations. The results will likely help bridge the gap between the uncertainties with assumptions (theories used) that have to be made and the inherent uncertainties with natural systems. This information will be used and built upon by the Implementation Steering Committee in designing the new regime for placer mining.

4. **What are the limitations to the growth of the industry, and what is the forecast for the future?**

- There are economic limitations in every industry. Placer mining has been a traditional industry in the Yukon, where people could build up their capital and resources over time. Now, with the production equipment needed and the regulatory requirements to be met before initiating a project, coupled with lower grade deposits; there can be a time and economic barrier to development.

- Also limiting are gold reserves. Significant reserves have been mined out in the last 2 decades and only minimal prospecting and exploration work has been accomplished to maintain the reserve of economic ground available to the industry even for maintenance of existing industry activity levels. Many operators are now mine planning 10 to 20 years ahead in order to ensure recovery of the increased capital investment. This tends also to limit the available reserves to existing operators.

- Expansion of the industry will be constrained by the very limited new reserves that have been discovered or expected to be discovered and reserves that exist on First Nations' settlement lands that have been held up during the claims negotiating process. These reserves may develop as part of the First Nations economic development plans.

- Future growth of the industry even with strong price incentives may well be significantly constrained by the current level of regulation.

Oil sands mining industry:

Canadian Natural Resources Limited (CNRL)

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1. **What are the priority research/information needs regarding diamond mining/placer mining/oil sands development (as appropriate to the industry response) and aquatic systems?**

- The research and information needs are driven by DFO requirements to understand what the HADD is for the diversion of river systems and the validation of compensation to meet the "net gain" or "no net loss" policy. This includes all analysis and methodology in the collection of pertinent data in order to support a variety of assessment methods and tools. To begin, this includes how streams are assessed for habitat as there is a wide diversity of professional opinion in as simple a task as measuring stream width or reach length. This is very complicated for beaver dams, and marginal forage fish habitat where the width, depth and length of the dam is transitory yet is required to be compensated for. In addition, fish species distribution determinations are currently done based on professional opinion, with field data used only as a starting point, as the absence of data on a species, regardless of effort of monitoring does not exclude the potential for its presence. As a result, this can require multiple years of sampling as there is no accepted methodology to validate this.

- The development of habitat models is extremely lacking, both for species of low value such as forage fish and for site- or perhaps even river-specific methods to calibrate or validate models for all fish species in the oil sands area.

- On this topic there is also little understanding in the region on how to develop and measure productive capacity for rivers and lakes in order to calibrate between the two for comparative purposes of compensation, "no net loss" assessments. This further translates into requirements to undertake meaningful monitoring programs, which require design, to document the achievement of "no net loss." The monitoring is required to fulfill two tasks, a validation of a methodology of HSI models to productive capacity and the actual measurement of productive capacity to document the change between the loss of river systems and the compensation of lake systems to address fish assemblage differences of marginal forage fish habitat, to that of sport fish habitat and the overall difference to "no net loss" of sports fisheries.

- There is also no valid mechanism of incorporating traditional knowledge into some of these assessments. The current methods are essentially number model based processes which do not lend themselves to traditional knowledge. Perhaps one being objective or with "professional opinion" as compared to a subjective traditional knowledge opinion.

2. What are your opinions regarding collaboration with DFO/universities/other industries?

- This is an essential part of research. It must include all sources to be representative, which will enhance credibility. It should also include traditional knowledge where appropriate. It is not desirable to proceed with research that is undertaken only by a company, a university or a government as it may not be inclusive enough in its scope and it will likely come under scrutiny for any suspected bias.

3. Regarding compensation/restoration actions, who decided upon that which was appropriate, who assesses the success/failure of them and what are the measures of success?

- I have addressed this under the first question. [The research and information needs are driven by DFO requirements.]

- [With respect to assessment of success/failure of compensation/restoration] This is unknown at this time and is not being clearly answered, however, it is the opinion of Canadian Natural that the standards for this must be set by the regulator, DFO, and can be transferred to the proponent of the project once the methodology is accepted and is reasonable for the compensation/restoration being assessed.

4. What are the limitations to the growth of the industry, and what is the forecast for the future?

- Honestly, the limitation to growth today, based on the rigorous review process that is undertaken, is acceptance and authorization by the Federal Responsible Authorities, primarily DFO.

- This limitation is predicated on the lack of the information identified in response to question 1 above. For our project a process of discussion, data acquisition, negotiation, documentation, modeling, etc. over a three-year period has done little to address the concerns of DFO on "no net loss," compensation/restoration or any other aspects pertinent to the authorization of the project despite the $100,000s spent on attempting to achieve those objectives.

- Clearly-focused research or development of acceptable methodology to be able to assess and document what a HADD is and what is viable and acceptable compensation are the most outstanding items to oil sands development. All other issues have been addressed in a timely manner and do not contain any constraints.

- As the future oil sands expand, water will remain the highest priority and the area of most interest and need for assessment and analysis for authorization. Water and what is under the water are also the least understood elements, as they relate to fish and fish habitat. This has resulted in the redefinition of assessments such as the in-stream flow needs (IFN) work examining under ice conditions of the Athabasca River

Suncor

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1. What are the priority research/information needs regarding diamond mining/placer mining/oil sands development (as appropriate to the industry response) and aquatic systems?

- One of our key issues is the difference between the levels of natural and anthropogenic chemicals within the natural environment (particularly the Athabasca River).
- Our processes add little if any new chemicals to separate the bitumen from the oil sand – our wastewater streams can contain naturally occurring chemicals (e.g. naphthenic acids). These chemicals are released to the river naturally (bitumen flows down embankments directly into the Athabasca River) but there is currently no way of distinguishing the origin in the environment.

2. What are your opinions regarding collaboration with DFO/universities/other industries?

- I believe that collaborative research is the most effective method of achieving research results that meets the needs of a variety of interests. Working with universities is a very cost-effective (although not always time-effective) method of having research carried out with some degree of third-party credibility. I would encourage DFO to continue collaborative research wherever possible.

3. Regarding compensation/restoration actions, who decided upon that which was appropriate, who assesses the success/failure of them and what are the measures of success?

- I assume this question is related to 35(2) compensation.
- Our experience indicates that DFO alone decides what compensation is appropriate for a given HADD. However, exactly what is "appropriate" compensation is not clear to industry.

  As far as follow up, it is generally left to the applicant to do the monitoring to determine the success of particular compensation and the applicant generally recommends their own measures of success.

4. What are the limitations to the growth of the industry, and what is the forecast for the future?

- In my opinion there are currently no limitations to the planned growth of the oil sands industry in the Fort McMurray area.

- The Cumulative Environmental Management Association (CEMA – of which DFO is a member) is currently looking at environmental thresholds associated with development in our region. Although the work is still continuing, to date no "hard" environmental thresholds have been identified, however, additional research and monitoring programs have been initiated to confirm this assumption. The oil sands industry currently produces in excess of 500,000 barrels/day of oil products for North American markets and this is likely to at least double over the next 5-8 years.

Albian Sands Energy Inc.

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1. What are the priority research/information needs regarding diamond mining and aquatic systems?

- Research priorities should be related to the real impacts of developments.

- There are different degrees to which habitat can be altered, and given a "head start" nature is capable of restoring itself.

- "Tools" are required, for example, concerning the rebuilding of a stream. We must rebuild water systems using the tools that are available. When an area is reclaimed this is relatively easy to do, and overall, mines produce very small "footprints."

- First level of reclamation that we consider is strictly physical – an engineer's first assessment. Many people want a cook book for these activities. However, one cannot always rely on a cook book, for example, in an area where one might expect beavers, a stream or a water course would be reclaimed differently.

- We are doing a lot of riparian research: *$300 K was spent over 2 years studying the vegetation, moisture, nutrients, etc. (controlling factors) alongside natural streams.* There is not a lot of information on riparian reconstruction. The physical part of river engineering — is fairly easy.

- Wetland (water-covered land) reconstruction is easy but not a lot is known about the holistic approach to stream reconstruction. *At Albian Sands a buffer of 100 m has been placed adjacent to all water bodies associated with our mine for stream protection and to provide a wildlife corridor.*

- Reclaiming back to the original muskeg is difficult for several reasons. The flat terrain and the oil sands below the land surface provide a good waterproof barrier preventing the muskeg from draining. Once the bitumen has been recovered from the oil sands the remaining sand is quite permeable and free draining. With little moisture holding capacity it would be difficult to reclaim this land because of a moisture deficit, and in reclaimed terrain, where there is no water retention and more water evaporates or drains away from the ground than falls as precipitation, it will be difficult to establish vegetation.

- Reclamation takes a significant length of time to realize. Mining activity will continue on our lease for 30 to 40 years. We are doing progressive reclamation during this time and not waiting until the end to start these measures. As such we need to have long-term plans in place to help minimize reclamation costs. Without a plan it is possible for waste dumps to be placed in the wrong locations, or water body elevation change at the closure of the mine. Mine plans do change frequently but good "up front" planning goes a long way to reducing the cost.

- Another priority research area is that concerning end pit lakes. The last pit mined typically fills with water and becomes a lake. The earlier in the process that one can decide upon a final elevation the better as it will allow one to plan for an appropriate littoral zone so when the end pit fills, a 2-m deep zone with soil exists along the shore to allow aquatic vegetation to establish itself. To fill an end pit lake we could, for example, pump water out of the Athabasca River over 7 years, or allow the pit to fill on its own over 30 to 40 years. If it is fills slowly, contaminants in the groundwater table could migrate into the pit over time. To avoid this contamination it is preferable to fill end pit lakes quickly. However, water extraction rates should not exceed what the source can provide.

- We will end up with a lake when a pit fills. If done correctly this could be considered to be compensation for lost habitat. We need to ensure that the lake is useful to fish. During the development of the mine, 80% of muskeg is going to be converted into upland terrain. It is possible to ensure that all lands drain through end pit lakes, so we may ensure that all organics break down before the water subsequently enters another watercourse.

- The breakdown of organics is not fully understood however, we have studies in progress through industry, government and universities that are addressing the topic. We participate in CONRAD [Canadian Oil Sands Network for Research and Development].

- In contrast with that which can be accomplished by the companies involved with oil sands mining, placer miners such as those at Atlin, BC, are very small operators with small operating margins. As a result, they cannot begin to do 1% of what we have done in research.

2. What are your opinions regarding collaboration with DFO/universities/other industries?

- CONRAD is a recognized successful model.

- The concerns of the Aboriginal community are brought to the table through our involvement with other multi-stakeholder committees such as the Cumulative Environmental Management Association (CEMA), Regional Aquatics Monitoring Program (RAMP) and the Wood Buffalo Environmental Association (WBEA). There the Aboriginal community is directly involved in the decision making.

3. Regarding compensation/restoration actions, who decided upon that which was appropriate, who assesses the success/failure of them and what are the measures of success?

- We carry out a variety of restoration activities and other industry members want to be involved with us. A lot of work is being done on the reclamation of soil and vegetation, wetlands, and aquatic habitats – 40 committees and subcommittees are active in these areas. *For example, working groups are active in surface water quality, in-stream flows, sustainable ecosystems, (which considers what is required as habitat for wildlife and fish) and reclamation of soil and vegetation.*

- The Alberta government has representatives from the sustainable development ministry who ensure that we grow a commercial forest.

- Native groups want the muskeg back, but rehabilitation measures will not satisfy everyone in terms of muskeg, forestry, blueberries, etc.

- Our riparian work focuses on the plants – nobody told us if the fish need those plants – we are just replacing what was there.

- Mineralized areas are where metal mines are located – an anomaly in nature – there is more metal in the habitat than otherwise. A perfectly good stream could be naturally devoid of fish because of mineralization.

- Mine development does however speed up the erosion and mineralization of streams.

- Considering compensation, *at Highland Valley Copper in south central BC, there was money to fund habitat improvements for a 60-mile radius around the mine. Local sports fishermen, government and mining interests reviewed the project proposals some of which include the construction of spawning channels.*

- We need to focus restoration where it can do the most good, such as where there is greater productivity, or in places that were productive and were destroyed a long time ago.

- We should be able to compensate for disturbed habitat with money.

- Also we need to compensate in other environments that are more productive than at mines where there is mineralization and low aquatic productivity.

- The use of wilderness areas is a major issue. Our lease is 3 townships in size; this is a large piece of land.

- *With Fort McKay elders we are trying to use traditional ecological knowledge (TEK) to restore habitat and to "heal" the land. My reclamation and landscape team meets with Aboriginal elders to hear how they can participate in the reclamation process – moose habitat, fur bearers, duck habitat, fish. The Fort McKay community is completely surrounded by large oil sands mines. Allowing them to participate in the reclamation process or "healing the land" can be therapeutic.*

4. What are the limitations to the growth of the industry, and what is the forecast for the future?

- The world's demand for oil will ensure that the industry here continues to expand. The Athabasca is a big river which is capable of providing the water we need. Industry recognizes the need to reduce our water use. The Alberta Government is starting to realize the need to conserve water.

- The closure of the Geddes Resources mine – Windy Craggy – shows people can shut down a mine.

- There are limits to growth and attitudes are changing. Diamond mines helped to change things for the better. Mines have made a valuable contribution to understanding our northern environment. How little we know about the boreal forest. I am sure it is the same in the tundra. When mining areas in Indonesia, scientists found a new endemic species every time we went out. A lot can be learned by approaching mining in a pragmatic way.

- There are limited financial resources. Industry on the one hand has a commitment to society and to science, but those same industry people hate wasting money. At the same time scandals in government reveal a poor record of money management.

- We need to work together. Our linkages with the University of Alberta and the University of Saskatchewan are stronger than with the research council. Certainly the federal government is very limited in what it can do.

Consultants regarding industrial activities in northern Canada:

Golder Associates Ltd.

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- On behalf of Golder Associates, I am pleased to provide the following information regarding research on fish and fish habitat in relation to northern industries. Whereas I appreciate that the scope of your undertaking may be focused on questions arising from specific or possibly cumulative impacts associated with various unique or specific project-related activities, I have focused on overall DFO project involvement in these developments. Whereas some of the issues that are raised may be superficially categorized as administrative issues, in fact, a substantial amount of research by DFO is required to deal with these issues in a scientifically-credible manner.

1. **What are the priority research/information needs regarding diamond mining/placer mining/oil sand development (as appropriate to the industry response) and aquatic systems?**

- The biggest information need from DFO, by far, is direction and a protocol for dealing with its Policy for the Management of Fish Habitat (the "Policy"). This, in turn, leads to what DFO should consider its research priority.

- While the intent of the Policy is admirable, and generally supported by industry, the policy is based on the concept of maintaining and ultimately enhancing the productive capacity of fish habitat in Canada. However, there is no direction or consensus even among DFO practitioners on how to achieve this goal. There is a dire need for a standardized, transparent, defensible method to address the harmful alteration, disruption or destruction of fish habitat, as a HADD is virtually unavoidable with oil sands developments.

- Once a method of determining a HADD is available and used, the next challenge is adopting a method(s) for valuing loss and determining appropriate compensation.

- There are few strong, direct links between fish habitat and "productive capacity" and habitat is too often assumed to relate to fish production. There is a mixed message whether habitat or fish is the primary concern. The critical need is, therefore, to identify the "best" measures of habitat and the features of fish communities that are important (e.g. distribution, community composition or fish stock abundance).

- Further, while the intent of the policy is the replacement of damaged natural fish habitats through compensation activities, when working in virtually pristine areas such as the oil sands region, the replacement of previously-damaged habitats is not an option.

- Direction is required from DFO on how to achieve the Policy objective of a net gain in fish habitat in these situations.

- Currently, the interpretation of how this objective may be met in these pristine areas varies with the DFO practitioner involved.

- In the oil sands region, abundant opportunities exist for significant net gains in fish habitat in the watercourses and lakes (end pit lakes) that will exist on the reclamation landscapes.

- These opportunities tend to be discounted by DFO, with the apparent attitude that these habitats will not be productive because they will be in contact with processed materials, and, during reclamation, credit will only be accrued for an increase in productive capacity if and when project proponents demonstrate functioning aquatic ecosystems in these environments.

- In the bigger picture, this is possibly the biggest opportunity for creating net gains in productive fish habitat, as at this stage of development each project will have already achieved the "no net loss" principle.

- DFO should continue its involvement in, and possibly substantially increase its role in research projects designed to provide guidance in the development of productive, sustainable aquatic environments on the reclaimed landscapes.

- Other research areas that DFO may want to consider specifically in the oil sands region relate to the response and adaptability of the aquatic resource to petroleum hydrocarbons in its environment. Specifically, the aquatic ecosystem has been exposed to natural releases of petroleum hydrocarbons which have been the subject of some study. With the increased abstraction activities in the oil sands, what is the likely response of the aquatic ecosystem to increases in the release of what may be considered naturally-occurring substances. In this context, the issues of fish tainting, and fish health risk assessment are worthy of further investigation.

2. What are your opinions regarding collaboration with DFO/universities/other industries?

- More collaboration among researchers from the regulatory agencies, universities, industry and other players can only be beneficial to the maintenance of the aquatic resource, and is strongly encouraged.

- There is opportunity (and benefit to be gained) by investing cooperatively in joint ventures where: a) different measures of dealing with habitat or fish communities are tried without jeopardizing issuance of an authorization; b) different compensation measures can be applied without assurance that the goal is met but the intent is, however, delivered; and c) compensation is "managed" or adapted to achieve the intent. While there is opportunity for experimentation and collaboration, there are few examples where it has occurred to benefit the resource.

3. **Regarding compensation/restoration actions, who decided upon that which was appropriate, who assesses the success/failure of them and what are the measures of success?**

- The decision on the appropriateness of compensation/restoration actions is simply that of the DFO practitioner involved. Varying degrees of effort are expended by the various practitioners on obtaining input in this context from the relevant NGOs, although project proponents typically focus more energy on this activity than DFO does. The DFO practitioners also tend to consult with their Provincial counterparts when decisions are being made about the appropriateness of the compensation undertaking.

- The measures to be employed to determine success/failure are typically specified prior to the issuance of a section 35(2) authorization by DFO, which is appropriate. In most, if not all cases, the onus is on the proponent to develop compensation options, and to determine success/failure criteria, which are presented to the DFO practitioner for their comment.

- Typically, the proponent is required to continue the development of such options until the DFO practitioner is satisfied. The onus is also typically on the proponent to collect the necessary information to allow a determination of success or failure. However, in reference to all three components of the question (appropriateness, success/failure and measures), virtually every section 35(2) authorization contains the phrase "to DFO's satisfaction," which rightly or wrongly may be interpreted as "to the satisfaction of the DFO practitioner," such that it is quite clear who the decision maker is in terms of whether these objectives have been met.

5. **What are the limitations to the growth of the industry, and what is the forecast for the future?**

- This question is best referred to industry.

M. Miles and Associates Ltd.

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Discussion was held in relation to the 4 questions posed to industry, however the main focus was on placer gold mining, diamond mining and habitat restoration.

- It is difficult to create ecologically-functioning streams, and a better option is to seek ways to increase access for fish to other habitat that is not used by them. For example by removing barriers, but who would do this?

- With respect to [aquatic] vegetation in northern regions the time frame for growth is prolonged, and there is the danger of hypoxic conditions through the use of fertilizers used to stimulate growth.

- Instant-functioning ecosystems are difficult to create but do not rule out the short-term benefits that can be obtained through restoration measures.

Placer mining

- Question of how long does placer mining elevate sediment in waters; it is currently regulated based on an end-of-pipe measurement. This is not very relevant because channel slope and instability play a major role in the introduction of sediment into streams.

- *Abandoned sites for example, may have sediment settling ponds that have failed in most places and their contents have entered the streams. Settling ponds in many instances breach.*

- What has happened to the very large amount of sediment that was produced in the gold rush? There is a legacy of issues from which we can gain some insight for future decisions.

- *Indian River valley – the valley has been eroded and changed over time. The sediment coming from ponds is but a small part of the sediment movement and deposition in the system. Based on aerial photographs over many years it is possible to trace the downstream movement of gravel deposits.*

- The Indian River was an oligotrophic stream surrounded with vegetation but its transition over tens of years has created a wide, shallow valley, with numerous side "lakes" and in the short term, warmer conditions. The positive or negative consequences of the change are not known.

- The temporary storage of sediment in settling ponds does not assist with management of fish habitat, and in general, little is known about channel stability and gravel movement in these unstable watercourses.

- Channel morphology changes occur over a very long period of time. *In the Klondike there are still effects due to events of more than 100 years ago.*

- *In the McQuesten River there has been very little re-vegetation since the mining in the 1950s.* What determines this type of recovery, and what bioengineering is required, should be addressed, however, there seems to be little funding for this type of work.

- There is still a lack of basic biological knowledge regarding how fish use the northern environment. For example, would off-channel habitat that can be created in warmer regions be successfully employed in northern regions to aid fish use of disturbed habitat, or compensate for that which has been lost? *In the Mayo area there is off-channel habitat but not enough is known about fish movement to assist in the design and implementation of such features.*

- Groundwater that can feed such areas would be very cold or non existent in the north, so information is needed regarding fish use and movement to and within these areas.

- If one does not know how fish use these areas how does one design for compensation?

Restoration

- The restoration of mined sites is difficult because often miners want to re-mine to get more gold.

- Consider that mining plans should incorporate bioengineering of sites.

- Assessments of the morphology of channels are required for it is likely that the sediment regime and slope of the stream will be altered and reforming a channel would be difficult. Therefore what the channel must be restored to is a valid question. A report on restoration has been written for A. von Finster, DFO, Whitehorse.

- Although benthic community integrity is affected by placer mining, it is also necessary to address the issue of terrestrial food production and streamside stability (riparian zone). For areas that have been previously dredged it may be possible to expose the finer material beneath the upper coarse material and by doing this vegetation growth would be enhanced. The fine material assists with the retention of water. *In the Dawson area some "restoration" occurred by removing the tops of gravel/sediment hills and deposits. However, in some streams the previous meander has been replaced by a channel by which thermal erosion can occur alongside valley walls leading to increased sediment input to streams.*

- There is a need for the rates of recovery of disturbed watercourses to be assessed over time.

- To assist in this there is a need for a compilation and assessment of aerial photographs over large areas and over time (it is difficult to address the magnitude of mining from the ground).

- Quantification of short-term (10-20 years) impacts and changes is also required.

- Restoration is very costly, and the cumulative impacts of mining are unknown. There is a need for scientific studies to show what happens over time (impact and restoration); cumulative impacts are unknown.

- Basic scientific research is required similar, *for example, to the 25-year Carnation Creek watershed project on Vancouver Island, BC*, that addressed ecological effects due to logging and other forestry practices).

Tundra

- Streams that are small behave differently than, for example, the Coppermine River.

- There is little or no information on discharge data and small stream data are important. Often peak flows occur when channels are ice filled.

- It is very difficult to design channels because the appropriate data are not available. So, movement of barriers to permit fish access is probably more likely to be successful as a compensation technique than creating small streams. "It is possible to make more bedrooms, but can you make more kitchens?"

- Fidelity to sites is a topic for study (*Dave Bustard, Smithers recorded bull trout fidelity to spawning reaches in relation to the Kemess Mine development in BC).*

- Need to assess factors that relate to habitat use – basically a definition of characteristics to identify the site requirements (proximity (<5m) to cut banks, transverse riffles, and proximity to tributary).

DFO Habitat Management

Pacific Region

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1. **Is there a formal or informal decision-making process whereby habitat managers are able to assess impacts on fish and their habitat?**

- Yes. We use the Habitat Policy (1986), the HADD Decision Framework (1998), the C&P Guidelines (1998) as well as the wealth of professional experience and judgment available from the habitat assessment biologists.

- In addition, large mining projects are always reviewed as part of the joint federal/provincial review process that operates in accordance with the Canada/BC Agreement on EA Co-operation. This process typically involves a multi-stakeholder review team that includes federal, provincial, municipal and FN representatives. Our CEAA requirements are met through this harmonized process.

2. **How are fish and fish habitat loss dealt with in quantitative terms? What are the species/habitats of concern?**

- We require a detailed habitat inventory of the proposed area of impact. In addition we will ask for data on fish species, numbers and utilization of the various habitats. With this information we use the area impacted of a particular type of habitat (area acting as a surrogate of productive capacity), with a multiplication factor to deal with uncertainty (compensation ratio); or if a limiting habitat factor in the system can be identified we will focus the compensation efforts towards that limiting factor. When one can get more value by removing a "bottleneck" we are confident in knowing that compensation has functional significance and is not just like-for-like replacement.

- Habitat that has been identified as limiting will be the habitat of concern and may even be characterized as "critical" habitat. This will vary from project to project.

- Species that are listed provincially or in SARA are of concern as well as important commercial, recreational or FN traditional species.

- Special consideration is also given to those populations that are unique. For example we had a situation where a hybrid species of charr was identified that warranted extra protection because of its uniqueness.

- Compensation ratios are developed for all proposals where an authorization is given. These will vary depending on the specifics of the project.

- Compensation proposals that have a higher risk of failure will have much higher ratios, sometimes 5:1, in order to ensure success. For example on a road development along the estuary of the Nass River, the primary impact was to salt marsh habitat. Earlier attempts at restoring salt marsh had met with mixed success for this project, if I remember correctly, it had a replacement ration of 5:1. Although we conducted the assessment, the details of the authorization were worked out by our Prince Rupert office and my understanding is that years later, even with the high ratios, the replanting has not equaled what was lost.

- In other situations we may require specific contingency plans that would apply if performance criteria of the compensation are not met, or there is a high risk of failure. Or there may be some combination of ratio and contingency plan.

- We do not use a Habitat Sensitivity Index (HSI) but we use the area impacted of a particular type of habitat (area acting as a surrogate of productive capacity). This is an example of applying a weighting factor to a particular habitat type. *We have found that the use of HSI and Equivalent Habitat Area can be very subjective and they have usually been developed for some other part of the country or continent and are not applicable to the particular system being evaluated.*

- Note that when consideration is being given to whole lake destruction, the circumstance is actually the destruction of a whole ecosystem. In such a situation, critical habitat, by definition, for that functioning ecosystem would be destroyed. Special consideration is supposed to be given to critical habitat and authorization should only be considered in rare circumstances as per the C&P Guidelines.

- Consideration of compensation for whole ecosystems is certainly beyond the scope of any assessment process or habitat biologist's expertise. Even with a very comprehensive habitat inventory and fish utilization study it would likely be impossible to recreate a lake ecosystem with all of the associated interactions and contributions to the surrounding environment. And if it were possible it would likely be prohibitively expensive.

- In Pacific Region there is the Watershed Fish Sustainability Planning initiative that promotes an "ecosystem-based" decision-making system. I am curious as to how proposing to authorize whole lake destruction (which are certainly ecosystems in their own right) fits into this initiative.

3. **How are cumulative impacts addressed? Is there concern at the fish population level, the lake and/or watershed level?**

- For projects where components of fish habitat are being impacted, and if we are compensating properly, there should be no residual impacts to be considered as part of cumulative impacts assessment.

- With the major projects that we deal with, our monitoring reports have suggested, through our qualitative assessment, that we have been very successful in meeting NNL. The Quigley and Harper report did not examine our projects in any depth because of the size of our files associated with the review of very large developments.

- If the question is being posed in the context of whole lake destruction proposals it is difficult to comment.

- How many lakes can be destroyed in an area or a region before one considers it an unacceptable cumulative effect? This is a highly technical and difficult question to be answered in the context of DFO policy or a CEAA assessment. The answer to this question lies in the significant political and social issues that surround the technical considerations.

4. What knowledge and policy gaps exist and how is this dealt with in decision making?

Knowledge Gaps

- There are numerous areas where knowledge gaps exist in our work but if I am to take the question in the context of large mine developments where whole lake destruction is proposed then I would refer to my earlier comments in response to question 2.

- How does one recreate the interactions/associations, etc. of a functioning ecosystem? While one might be able to identify the components being impacted and attempt to compensate for them, getting everything just right so the components function as hoped is a huge challenge, if not impossible.

- How do you ensure the maintenance of water quality? The balance of primary productivity vs. nutrient addition? Nutrient turnover? Winter survival? Predator-prey relationships/balance? Spawning/rearing/feeding/refuge habitat locations and balance? Not to mention the interaction of a lake with the surrounding plant life and wildlife, downstream hydrology, flow attenuation and water quality, etc, etc.

- Each lake is different and would require years of study to get a basic understanding of how it all works. Even more science would be required to understand how to put the pieces back together in a way the might recreate what is being lost.

Policy

- The authorization/compensation part of the Habitat Policy focuses on the component parts of an ecosystem – not on entire ecosystems that we see involved with whole lake destruction or massive tailings disposal facilities that impound entire valleys. One could argue that lakes or valleys are themselves component parts of larger ecosystems but at what point does one consider that a risk is too great?

- As previously stated, I would argue that the Habitat Policy is intended for smaller habitat losses where the impacts are understood and quantifiable and the proposed compensation has a reasonable chance of success and where the consequences of failure are manageable.

- To suggest that the same policy and approach can be used for a small stream reach and an entire lake is not reasonable.

- At some point the level of complexity becomes so great and the impacts so large that it is not physically, economically or biologically possible to compensate for habitat impacts.

- When this point is reached the decision to destroy a lake or other large system is no longer based on technical arguments and becomes a political, social or separate policy decision.

- There needs to be a separate policy or departmental position that comes into play when a project proposes to destroy habitat of the magnitude seen with whole lake destruction.

5. **How is uncertainty incorporated into the decision-making process regarding compensation?**

   Uncertainty is handled in several ways.

- Compensation ratios (up to 5:1 depending on the situation), performance criteria for the compensatory habitat (e.g. use of spawning beds, riparian planting success), approved contingency plans if performance criteria are not met within the specified time frame and financial securities are always required in case of a default by the proponent.

- Regular monitoring and reporting is also always required to determine compliance and success. We may use some or all of these strategies depending on the risk associated with the project.

- With respect to whole lake destruction, the magnitude of impact and the unknowns/risks associated with such a proposal make it difficult, if not impossible, to propose a mechanism to ensure that DFO policy is met. Such a proposal requires more of a political/social decision than a technical one.

6. **How is habitat restored in the northern locations of BC? What are the pros and cons? Are there case studies (success and failure)?**

- We have had instances where compensation for habitat components has been somewhat successful.

- One of the key difficulties is the remoteness of impacted sites which results in us relying on monitoring reports. Others issues are the extreme weather situations that make construction of compensation measures difficult (short work windows) and maintenance required to ensure continued function (e.g. fish access). Spring melt can lead to huge challenges in surface water and sediment control.

- *Kemess South mine is an example of a development with both success and failure regarding habitat management. The company was charged and convicted under* *section 36(3) of the Fisheries Act because of massive inputs of sediment into fish-frequented waters. However, the compensation works (e.g. fish-way for bull trout), although years late in being implemented, have been judged to be successful. However, relative to a whole lake destruction scenario, Kemess South was a relatively simple authorization and required compensation for loss of the headwaters of South Kemess Creek and associated flow impacts downstream. The length of stream impacted was approximately 12 km with an additional loss of 5 km of a small stream due to the waste rock dump. The width of these streams was typically less than 1 m. Even so, with the pristine nature of the surrounding environment it was difficult to devise compensation measures that did not in themselves pose additional environmental problems – another key challenge in remote locations.*

7. What initiatives (and who is doing them) are underway to fill gaps in knowledge and improve decision making over damage to fish and their habitat?

- *In northern BC, at the Kemess South mine development which we authorized in 1996, the compensation plan for the TIA included a significant research component. Specifically, research on bull trout life history has been very valuable and is still ongoing. Key to the success of this research has been the use by the company of a single consultant (David Bustard and Associates) which has been very diligent in ensuring that the information has been collected regularly and analyzed in a consistent fashion. As part of the federal and provincial approvals process, a federal/provincial steering committee was struck that meets annually with the proponent and its consultants to review the information and provide guidance on the research.*

- *In addition, the proponent has made facilities available to graduate students, allowing them to conduct research on the site.*

- *All of this information has added greatly to the understanding of bull trout life history and habitat requirements and preferences and will assist DFO in future developments that have the potential to impact charr species.*

8. What initiatives (and who is doing them) are underway to examine fish habitat compensation and restoration activities?

- Quigley and Harper (DFO) have evaluated the success of the NNL components of the Habitat Policy based on case studies across the country. Their review has been valuable in identifying the success of the program in meeting NNL. Unfortunately, because of the size of the projects and the files associated with the reviews handled out of this office, they were not included in their report.

- All of our authorizations have a requirement for monitoring for compliance and effectiveness (against performance standards such as utilization and growth/success).

- Depending on the project we may require that the monitoring be conducted by consultants that are at "arms length" from the proponent so that we get unbiased reports.

- The criteria for success are usually developed in collaboration with the proponent as is much of the rest of the authorization.

- *Examples are: # of redds in created spawning areas, # of juveniles/100 m of rearing habitat, # of live plants/area for riparian planting, etc. There may be a number of targets that need to be met over the course of several years or there may be one target after 2-3 years. It all depends on the circumstances.*

- In my opinion, a significant component of research is well-structured observation and reporting, and a well-designed monitoring program incorporates these.

- The reports that we typically get from our monitoring requirements allow us to make decisions on the current project as well as use that knowledge for future projects despite the fact that it is not part of a peer-reviewed publication.

9. **Is collaboration with industry on monitoring/research ventures mutually profitable, and are there opportunities to further such co-operation?**

- Certainly collaboration has proven useful to DFO. For industry the value would depend on the individual company and perhaps the number of similar projects it has underway in Canada. There has been a lot of work done with DFO and the forestry sector in BC. As discussed above, detailed monitoring reports or specific research requirements that are part of an authorization have proven to be valuable for understanding impacts and the appropriate types of compensation.

- Many types of research involve experiments and this is an important part of gaining knowledge.

- However, certain experiments bring a level of risk with them that warrants careful consideration if the risk may be too great despite the desire for knowledge.

- For large or massive impacts to complex systems the risk of habitat loss is greater and the consequence of failure is large and the likelihood of failure is great. It is not appropriate to use compensation as an "experiment" in these circumstances.

General Comments

- With respect to the current knowledge, I believe that it is not reasonable to suggest that research could truly allow DFO to identify what a successful compensation plan for whole lake destruction would be.

- The magnitude and the complexity of such a compensation plan are beyond the scope of the current and foreseeable understanding, and this is the same for any complex system that has structure and function.

- *As an analogy, one could study a dandelion and have a clear understanding of how it works, its contribution to the surrounding environment and even sequence its DNA. All of this research would contribute greatly to our understanding of dandelions (or lakes). If one then put a dandelion in a blender (habitat destruction) we would then have all this information as well as all the components that make up a dandelion. Is it reasonable to suggest that we could then recreate a functioning and structurally-equivalent dandelion?*

- If one was to follow the Habitat Policy and the current guidelines then whole lake destruction would not be authorized because:

  i) it results in the loss of critical habitat that can only be authorized in rare circumstances and is required to be compensated for at or near the site of loss (C&P Guidelines 1998 p. 12); and

  ii) the unavailability of technically-feasible compensation options for lakes (HADD Decision Framework 1998 p. 15). As far as I am aware there has been no successful compensation undertaken for the loss of a fish-bearing lake.

- If one was to follow a Pathways of Effects approach to major developments impacting fish habitat, it would falter on the issue of unavailability of technically-feasible compensation options.

- Similarly if one were to take the Risk Management approach using the Risk Assessment Matrix, destruction of a fish-bearing lake would clearly fall into the red zone which is "significant negative effects." With that as an outcome, what do we do with it?

- If DFO approves it at that point then it is clearly not based on any technical or science-based arguments.

- My recommendation is that DFO take the position that we are generally not supportive of whole lake destruction. Otherwise DFO will continue to get proposals of this type and continue to struggle with them at the technical level. If a proponent proposes to destroy a fish-bearing lake as part of its development then it must present an argument to DFO and for it to even be considered it must meet certain key criteria perhaps based on size, uniqueness, usage, productivity, etc.

- It should also be communicated that every proposal that includes whole lake destruction, if considered by DFO, will automatically be sent to a panel review under CEAA.

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1. **Is there a formal or informal decision-making process whereby habitat managers are able to assess impacts on fish and their habitat? Depending on the answer…what is it or how is it done?**

- Through the Yukon Placer Agreement (YPA) there is a formal decision-making process based on the classification of streams. From that classification scheme comes the type of restoration channel that will be required post mining. Guidelines are followed for Type IV streams; all other classifications require compensation channels. Effluent discharge requirements are also based on the YPA stream classifications. Type I, II, and III streams contain salmonids (defined as salmon, trout or charr). Type I is spawning habitat; Type II is rearing (effectively, only juvenile chinook rear in these streams); and Type III is all other habitat where the fish support a fishery. Type IV streams have no fish or have fish that do not contribute to a fishery. Decision making on stream types I, II, and III is done on a site-specific basis. Habitat deferrals can be on Type I, II, and III streams. With Type Di streams, it means that there is a water quality deferral. Type Dii streams can have a habitat deferral. To date, all deferrals have been water quality deferrals, which means that under the YPA, discharges are based on a dilution model – a sediment level deferral. With Di streams, the physical channel cannot be disrupted or diverted, although high levels of sediment are allowed. Type Dii streams can be disrupted or diverted, but there have not been any Type Dii habitat deferrals. Streams that do get diverted are largely Type IV streams. These streams could have high populations of fish, but unless the Yukon Placer Committee (YPC) agrees that they support a fishery, or a defined salmonid, they can be written off.

- When an authorization is issued, DFO has management steps to follow: authorization, compensation, and monitoring/evaluation. As a working guideline, an authorization requires 2 weeks to negotiate. Where the degree of uncertainty is high, it takes one week/year of a practitioner's time to manage the authorization. If the practitioner issues 20 authorizations a year, the following year, the practitioner has to manage the 20 authorizations. This reduces the amount of time that the practitioner has to negotiate new authorizations.

2. **How are fish and fish habitat loss dealt with in quantitative terms? What are the species/habitats of concern?**

- In terms of geographic extent, just under 10% of the watershed area of the Yukon River within the Yukon Territory upstream of the US border drains into Type IV streams or into streams with water quality deferrals.

- Regarding species and habitats of concern, following is information specific to Arctic grayling:

Over-wintering areas may be located in larger streams and rivers, or in large or small lakes;

In streams and rivers, the over-wintering areas may be associated with ground water discharges (if the ground water is of sufficient quality – i.e. has a short residence time underground);

"Spring fed" or ground water over-wintering areas are of increasing importance as one goes north;

In the spring, grayling migrate to spawning locations;

The migrations appear to be initiated by stream temperature;

There is an apparently variable degree of fidelity to spawning areas, with some stocks/locations having very high fidelity and some much less;

Spawning generally occurs in low elevation areas relative to the over-wintering areas and may occur in the outlets of lakes;

No redd is dug. Eggs incubate swiftly and the larvae emerge in late spring/early summer. Juveniles generally grow swiftly in their first year, and may approach 100 mm fork length by summer's end;

After spawning, adults move to summer feeding areas;

The areas may be upstream or downstream of the spawning areas, or the migrations may be more complex;

It is thought that sub-adults follow the adults and imprint on the migration route;

Some adult grayling will migrate as far upstream as is possible in any given creek in any given year. They are, therefore, seasonally the most wide-spread fish species in the Yukon River drainage basin;

There are also a wide range of other life history strategies – some remain in lakes all summer, others in bogs, others stay in or move through rivers and streams where at least some form massive schools for at least parts of some summers;

Grayling are generally observed/captured in clear (transparent or stained) waters;

Grayling are occasionally found in naturally-turbid water, and may be common in the mixing zones where clear water tributaries enter turbid waters;

They will also migrate up turbid streams. They may be stopped by dams or other obstructions in these streams, or be entrained in mine water and deposited in tailings ponds;

For all stocks, the window of meaningful feeding opportunity is quite narrow, comprising May through October, and varying from year to year with weather and climate;

Food is located by sight, and individuals will strike anything of the right size in disturbed or turbid waters. This can include non-food items (e.g. wood chips, root tips);

As water temperature falls in the autumn, most grayling return to the over-wintering areas;

The migrations may be significant, and comprise many tens of thousands of fish; First Nation traditional fisheries followed these migrations, and the locations of fish traps may be used as an indication of the relative strength of stocks.

Apparently there has been no DNA analysis on Yukon River grayling. The geno- vs. phenological debate has not really started. This notwithstanding, grayling swiftly colonize habitats that become available to them.

3. **How are cumulative impacts addressed? Is there concern at the fish population level, the lake and/or watershed level?**

- Cumulative impacts have not been addressed to date. A Strategic Environmental Assessment was initiated for Yukon Placer but appears to have been abandoned.

- Main species of concern is chinook – widespread, and they use non-natal streams. All streams without obstructions have migrating chinook juveniles – some cover large distances upstream (10s of kilometres) from migration routes.

- This industry is limited to flowing waters or to fossil landscapes beside flowing waters. Very few sites discharge into lakes. Where sites do flow into lakes, the effect is considered to be at the ecosystem level. For streams, we are dealing with primarily with chinook salmon. Yukon River salmon are managed as a metapopulation; they cross the border as adults. The juvenile salmon migrate downstream, but the out-migrant stock size is not monitored. We do not know the population dynamics of the fish in streams.

4. **What knowledge gaps exist and how is this dealt with in decision making?**

- Not much is known about population dynamics or how fish utilize habitat.

- People look at northern streams and try and fit them into southern paradigms.

- Habitat Suitability Index (HSI) has been used in the past, but appears to be a poor fit. If any part of the pathway breaks down, the population is impacted. Most of the information for HSI was based on studies in the southerly part of fishes' ranges, and on stressed stocks, *for example, Columbia and Sacramento stocks. Concern is that a chinook stock adapted to the Sacramento River is fundamentally different than one adapted to the Porcupine River, for example.* Going north, feeding strategies and ecosystem interactions differ. A chinook from the Fraser put into the Yukon River would become pike food very quickly.

- The Arctic grayling HSI is based largely on southern stocks. There may be enormous changes in annual abundance in grayling in streams in the north. *For example, if beaver dams block one of two tributaries – tremendous numbers of fish will congregate in the open channels, and few if any in the obstructed channel.* So you find high and low extremes in numbers of grayling in certain habitats – but we have no idea of long-range populations in a stream.

- One problem of northern fish species is that assessments are done by biologists for biologists. We need to integrate across disciplines, *for example, use geomorphologists to predict winter flows or channel forms/disturbance regimes.* For the 1993 placer mining studies, work was planned by a committee. Delays in planning led to lost opportunities.

- We do not know enough about fish movement. The majority of fish migrate out seasonally – fall migrations of some fish are well known by First Nations for food gathering. Most grayling will migrate out of streams in fall, but some 0+ and 1+ fish will stay in the streams. The die off in low-water winters can be large.

- We do not understand how predators affect populations in these streams. A merganser family goes up a stream and no juvenile fish are left; and so timing of sampling for juvenile fish is critical.

- More needs to be done to determine information gaps, and what the priorities may be for studies, investigations, etc. to address the gaps. A workshop should be held with practitioners and Science to explore this.

- Temperature is critical – food depends on it. *In a study done in Alaska it was shown that the depth of winter freezing varied significantly from year to year which can dictate survival of benthic invertebrates.*

- In terms of nutrients, in Yukon placer areas, there is not a lot of granite; the rock is mostly sedimentary or metamorphic. This, in conjunction with melting permafrost, results in runoff that can be high in total dissolved solids, leading to high primary productivity. It is different from Pacific coastal areas, or the Northwest Territories.

5. How is uncertainty incorporated into the decision-making process regarding compensation?

- Where a stream is laterally unstable due to past practices, there is no hope of creating a fish habitat compensation ratio of 2:1.

  It probably cannot be done in any flowing water environment. A channel is a result of gradient, flow regime, past practices and events. To achieve a 2:1 ratio means you have to reduce the gradient and lengthen the channel. A 2:1 ratio of habitat compensation for a Yukon stream which carries a fair bed load is logical.

- Compensation-in-kind was thought to be universally achievable and effective in the 1980s. We need to think past that.

- Where there is a stable environment, then on site compensation-in-kind, as per the 1986 Habitat Policy, is OK. But in unstable areas, we try to put the stream back into a structure it is comfortable with. Create more off-channel habitat, rather than like-for-like, and provide for food production, juvenile cover and support to other life history stages.

- If we consider that diversity is good, why do we have to have like-for-like? We are too tied up in process, and must move forward.

- Science and practitioners need to get together to decide on tools. Science builds the tools, practitioners use them. A tool is a building block.

6. How is habitat restored in the northern locations such as Yukon/Alberta/Northwest Territories/Nunavut – as appropriate re industry? What are the pros and cons? Are there case studies (success and failure)?

- There has not been any real restoration in placer mining.

- The placer mining stream restoration White Book was designed, apparently, on the hydrology of east slope Rocky Mountains streams. Operators fill out a worksheet on gradient and width, but it is not monitored, and it is subject to disturbance from the effects of upstream mining.

7. What initiatives (and who is doing them) are underway to fill gaps in knowledge and improve decision making over damage to fish and their habitat?

- The new placer mining management regime is being discussed, but so far not much is changing. There is the 50 Mile Creek monitoring, but it lacks adequate science input. We need to have an overall strategy to pull it together.

8. What initiatives (and who is doing them) are underway to examine fish habitat compensation and restoration activities?

- The new management regime may have components of compensation and restoration in it, but first we have to build trust working with the operators.

9. Is collaboration with industry on monitoring/research ventures mutually profitable, and are there opportunities to further such co-operation?

- There will be opportunities in time. We should not be looking at understanding the life histories of fish as part of a before/during/after study.

- We should set up a research watershed, where there is no chance of mineral exploration. A study is needed on how fish operate in an undisturbed environment.

Annex. The following additional comments were provided specific to watershed ecology and placer mining.

- Most of the streams that were placer mined in the past have been altered to such an extent that they will not be comparable as ecosystems to non-placer-mined streams for an extended period.

- A two-tier monitoring system is necessary: one tier to monitor the streams that have been altered/disrupted, and a second to monitor streams that have not been altered/disrupted.

- To define/describe "ecosystem health" in the context of "watersheds" requires consideration of the current definition of watersheds within the YPA and whether this definition needs to be revisited in the context of a new regime and definitions of ecosystem health. Ecosystem is defined as "a system formed by the interaction of a community of organisms with their physical environment" or "the study of the relationships between plants and animals and their environment."

- In the Yukon River, the "organism" used defines the "community." For example: slimy sculpin or chinook salmon or Arctic grayling. Arctic grayling stock separation, migratory behavior, etc. remains obscure.

- **Health** – "the overall condition of an organism at a given time; soundness, especially of body or mind; freedom from disease or abnormality; a condition of optimal well-being: concerned about the ecological health of the area." "Health" becomes a measurement of the condition of the ecosystem – which, in streams (in comparison to, say, deep lakes) is dynamic and has significant weather-climate-induced ranges of diversity and abundance of various species and of overall "productivity." Therefore the condition of an affected watershed would be related to a reference or "control" ecosystem on a real-time basis.

- **Watershed** – "the region draining into a river, river system, or other body of water. The whole region or extent of country which contributes to the supply of a river or lake." The YPA defines "basin," not "watershed." A basin supports salmonid spawning (the YPA definition of salmonid differs from the biological definition) and consists of a stream classified as Type I and all tributaries to this stream. Technically, YPA basins are not watersheds, but Management Units that were chosen for the administration of the YPA Dilution Model – first came the concept of the Model, and the Management definition of "basin" followed. The critical first question in respect of the New Regime is: will a dilution model be used? If not, then the reason for choosing the watersheds is no longer valid, and the definition of "Watershed" should be in accordance with the New Regime. The New Regime will, in this instance, have to recognize the fundamentally-altered nature of most of the streams that have been placer mined.

- If a dilution model is to be used (either the 1993 YPA or some derivative thereof), then the "watersheds" should meet the requirements of the new model: concept determines definition.

- **"Watershed Management" or "Watershed-based Management"** – an ancient concept – "To protect your rivers, protect your mountains." It is a fundamental planning tool. Resource management is integrated so that activities in the upper watershed do not negatively affect downstream resources.

- It is imperative that the indirect effects are also considered (the dilution model used in the YPA is effluent based), particularly those that persist after activities located upstream cease.

- It is critical to consider that the current level of placer mining on streams reflects the current economies of mining – if the price of gold were to rise significantly, there would be a great deal more activity. If the concept includes two or more tiers – i.e. "disrupted" and "non-disrupted" streams – the bar could be low on the disrupted streams (and be measured in the streams themselves, therefore avoiding the problem of the determination of mixing zones, plumes, etc.) and raised to be in accordance with other industries in non-disrupted streams.

- To measure health/condition use a surrogate. The obvious one is fish, beginning with their habitat:

- **Structure** – in most situations, and given a fixed precipitation regime, the structure of a non-disrupted stream is related to the gradient, parent material, glacial history and the size and structure of the upper landscape (i.e. the "watershed"). A vegetative community develops beside the stream – and contributes large organic debris through windthrow, bank erosion, etc. Usually, the smaller the stream the larger the influence of the large organic debris in providing stability and in creating lateral and vertical complexity in the channel.

- A non-disrupted stream is generally sinuous, has pools, riffles, glides, has a wide range of velocities and depths, and has a bed that often extends under the forest floor.

- The structure of a stream disrupted by placer mining tends to be straight, to have limited complexity (usually a long and constant riffle), and – importantly – to be constantly subject to high levels of sediments (not necessarily turbidity, as it includes bed loads) from upstream.

- **Food** – for fish in most placer areas – invertebrates, either aquatic/aquatic stages or terrestrial/terrestrial stages. Either way, they have to be available in sufficient quantity for fish to be able to successfully carry out their present life stage and be prepared for the next.

- **Water Quality** – sight-feeding fish must be able to see in order to feed and all fish must be able to successfully carry out their present life stage and be prepared for the next.

- **Water Quantity** – related to the first three bullets. Given a constant discharge of a contaminant, the lower the flows, the higher the concentration of contaminant; the lower the amount of fish food; and the more likely a stream structure will obstruct the migration of fish. Very high flows are usually accompanied by changes in water quality due to flushing, lower amounts of food, and over-bank flow.

- **Migration habitats** – almost all stream- and river-dwelling fish in the Yukon are seasonally migratory. Unless there are upstream over-wintering habitats, obstructions in the lower parts of streams will deny upstream access – fish will stop at the obstruction and densities may be very high immediately below.

- **Reproduction habitats** – these vary between species and in some species, between stocks. Spawning habitats may be easy for people to locate during or after use (such as by chinook salmon during a low water year) or may be almost impossible to locate (such as Arctic grayling habitats, except for those spawning in lake outlets or near roadways).

The fish of the Yukon which use flowing water for some or all life processes may be grouped as follows:

- **Migratory** (with the exception of slimy sculpin). The migrations of some species are relatively well understood, but others (i.e. Arctic grayling, all whitefish, burbot, etc.) are not.

- **Multiple stock.** Juvenile chinook salmon are probably the most notable – *in a non-natal rearing tributary of the Yukon River near Dawson there may be juvenile chinook salmon originating in the Nisling River, Michie Creek, the Nisutlin, Tatchun, Blind Creeks, the Mayo River, the Klondike River, and more.* For other stream-dwelling species and stocks, particularly Arctic grayling, the area of stock separation, recolonization of obstructed habitats, etc. is one that cries for research.

- **Largely non-territorial,** and which move upstream into habitats for unknown reasons, and out of habitats in response to disturbance/threat and in association with rapid environmental change (high water, sediment, etc.).

Fish sampling in Yukon streams:

- Each form of sampling works well in some situations, poorly in others;

- In respect of Yukon fish, sampling with seines, gill nets and electrofishing is most effective when the water is turbid. In clear water, fish see the samplers and escape. This is in comparison to fish in more temperate areas, such as trout, which are much more prone to move into cover – a hiding response. The effect may also be mitigated to some extent by the actions of the samplers. The escape response also occurs when staff setting block nets walk up or down the creek instead of out of sight through the bush beside it – they may herd the majority of the fish right out of the sampling site;

- Sampling with seines and electrofishing is more effective in simple channels, where there is no structure or cover as compared to non-disturbed channels with highly-complex structures;

- Sampling with seines and electrofishing is effective downstream of an obstruction to the species and life stages targeted following a period of upstream migration;

- Sampling with minnow traps baited as per the Yukon River protocol may be very successful for juvenile chinook salmon, sometimes for slimy sculpin, and ineffective for any other of the Yukon River fish species;

- Sampling with any gear will be less successful during summer high water events;

- Sampling with any gear will be less successful after the temperature of a stream dips below about 4 degrees;

- Relatively high numbers of fish will be captured after a period of low water compared to a period of relatively high water;

- Sampling stresses fish.

- Given the above, fish are, in my opinion, a poor surrogate for determining the condition of the ecosystems in Yukon streams, with the possible exception of slimy sculpin spawning success.

- Other fish species/life stages (e.g. juvenile and sub-adult grayling, burbot, lake chub, 0+ juvenile chinook) are poor surrogates for determining the condition of streams, at least as the presence/absence of wild individuals.

- To conduct a credible assessment of a mined creek in respect of a reference stream would be expensive – if used as a management tool, probably prohibitively so.

- Benthic organisms are probably a little better than fish as surrogates. There has been a tremendous amount of benthic sampling in the Yukon, and much of it was specific to placer mining. There may be enough data already collected to form a framework for determining an index of benthic integrity that could be used in the various placer mining areas of the Yukon (i.e. glaciated/non-glaciated). A drawback to the use of this methodology is that it does not account for much of the structure of streams, or the input of terrestrial food sources.

Central and Arctic Region

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1. Is there a formal or informal decision-making process whereby habitat managers are able to assess impacts on fish and their habitat? Depending on the answer...what is it or how is it done?

- Yes, there is a formal process engrained in policy in DFO for habitat harmful alteration, disruption or destruction (HADD). There is also a DFO HADD determination document; which has a flow chart whereby a stepwise approach is taken to determining whether a HADD is likely and whether authorization under the *Fisheries Act* is considered. It has similarities to the Pathways of Effects/Risk Management Framework (POE/RMF) and features standard assessment of what habitat is there; what fish are present; what impacts are likely; whether impacts can be mitigated; whether residual impacts can be compensated for.

2. How are fish and fish habitat loss dealt with in quantitative terms? What are the species/habitats of concern?

- We use the Habitat Suitability Index (HSI) times areal extent of habitat impacted. There are a number of versions of this.

- What is needed is a no net loss (NNL) procedures manual, so proponents and DFO know the ground rules.

- The currently-available model (HAAT) used south of 60° is not applicable to streams or northern systems. Proponents will develop site-specific information. We hope to get standard HSI tables with northern information.

- The use of HSI times areal unit is often highly subjective, but is difficult to test in the field i.e. how do you demonstrate that a given area of habitat post-enhancement is of a suitability of 0.75 vs. 0.25 under pre-enhancement conditions for lake trout spawning? We apply the same formula to losses as gains to address some of this subjectivity.

- We look at species individually, but need a table of HSI for individual species.

- In order to protect habitat for forage fish, we place a value on foraging areas. They use spawning and nursery areas, but we need better definitions of these terms.

- Habitat is evaluated on an areal basis; we quantify it in square metres of habitat. We often do not target some habitat uses directly, but we, for example, recognize that lake trout need forage areas.

- To quantify fish loss, we ask the companies to do some exploratory netting – a snapshot. Spawning is easiest to document, and rearing – beach seining – pockets of juveniles. Focus on these areas, as well as over-wintering and migration areas.

- We use a bathymetric map and figure out where the fish concentrate. A blockage to migration would be obvious. Foraging is not singled out, but it is difficult; we try not to discount forage species.

- A proposed targeted approach for assessments is to focus on fewer species and life stages to make monitoring manageable. *For example, with the lake trout spawning reef structure in Snap Lake, we know that other fish will use the habitat, and such other usage is recorded, but it is not used as a measure of success.*

- We should be targeting the most important species and life stages as measures of success. We do not consider rare species like pike. We know burbot and whitefish will use the habitat, and we assume crossover functionality of the habitat. We knew that the North Inlet [Lac de Gras] was abundant with juvenile cisco and a few juvenile lake trout. Therefore, a shallow rearing area should be created as a refuge for cisco (forage species). Areas do not need to support all stages of all species.

3. **How are cumulative impacts addressed? Is there concern at the fish population level, the lake and/or watershed level?**

- We do look at cumulative effects in a water body or stream.

- Sadly lacking is assessment of cumulative effects on a watershed basis. For example, there are projects in a stream; there is a dyke being built in Las de Gras, and pit excavation. These fish are slow to grow and develop and scientific sampling can disrupt function if too many top predators are taken. It is not known how fishing out a population will affect the overall watershed. Individual lakes are reported on. There is some indication of population assemblages, but no watershed assessments are done. We need a protocol for what to consider on a watershed basis. Multiple watersheds are in a basin. Watershed boundaries are set by where waters flow.

4. What knowledge gaps exist and how is this dealt with in decision making?

- What are habitat requirements between spawning and over wintering? What happens to the juveniles? Do they hide among the rocks, or do they use the deep-water areas? Where are the forage fish? Are they in rocky zones?

  Assume greatest production is in the littoral zone, which equals the depth of ice scour. In the south, the littoral zone can be equated to euphotic depth. Whatever production you get in summer in the north holds fish for the year. With rock at ice cover and a mud bottom, need to add diversity of habitat beyond the ice cover so it will provide more refuge area for juveniles. Over-wintering juveniles need a place to hide. Lakes have finite production, but there has been opposition to allocating it differently. If we force the system to reallocate it could crash and go back to equilibrium, and we would achieve no gain.

- In trying to achieve NNL, we are looking at a comprehensive approach: first we look at sunlight, water volume and then nutrient load. We must increase one to increase output. Adding rock may reduce production because volume would be lost. Therefore creation in the dry is the ideal way.

  In gaining access to a fish-less portion of a watershed, the production goes up in the watershed overall, for example, in a shallow area with good benthic production. Fish could over winter in deeper areas, so we could engineer a channel to provide access to areas that do not freeze too early. However, there has been community opposition to the enhancement of otherwise pristine habitat.

5. How is uncertainty incorporated into the decision-making process regarding compensation?

- DFO Science has used habitat compensation ratios of at least 2:1 to achieve NNL. This has been recently reviewed and higher ratios of 3:1 or 5:1 have been recommended.

- Practitioners need the time to do follow up evaluations of compensation effectiveness. We try for a 2:1 habitat compensation ratio, or higher if the risk is greater, and the habitat is more valuable. 2:1 is seen as one-third risk; one-third interim loss and one-third net gain. If, however, we see net gain as a DFO-only responsibility, then the 2:1 is one-half interim loss and one-half risk.

- Where uncertainty is high, we target more areal compensation. A Habitat Unit approach is used, but we need monitoring and success criteria. It could be generalized as a decision-making tree.

6. How is habitat restored in the northern locations such as Yukon/Alberta/Northwest Territories/Nunavut – as appropriate re industry? What are the pros and cons? Are there case studies (success and failure)?

- We have had some smaller projects go wrong, such as culvert placement. But so far nothing in the way of lake habitat compensation is in place for diamond mining. A lake trout spawning reef was placed in Snap Lake, but quantification of effectiveness is unknown. We have received some scientific advice, but there have been no actual studies.

7. **What initiatives (and who is doing them) are underway to fill gaps in knowledge and improve decision making over damage to fish and their habitat?**

- There is research funded by Ekati on the Panda Diversion Channel (PDC) – ecological and physiological. The University of Saskatchewan (Karsten Liber) is conducting research on Long Lake concerning impacts of coagulants, and benthic colonization of tailings. There was the Kodiak Lake Sewage Effects Study – a 3-year project.

- The monitoring that is going on is only as good as the data roll up. The trend series analyses are all based on water chemistry, which DFO is not directly involved in.

- In terms of fish sampling, the studies are on adults, meanwhile the juveniles could be compromised by food shortages.

- Aquatic Effects Monitoring is chemical focused. At Diavik, North Inlet would have been a natural candidate for experiments with nutrient additions, but timing of mining did not fit using North Inlet. *At BHP, Cell E of Long Lake [which receives tailings at the top end] is considered the first receiving water body, given that there are filter dykes between the cells. Therefore, if the company could backfill Beartooth pit, it could avoid putting tailings into Cell D. That would leave Cell E as the comparison cell for Karsten Liber's study of benthos in each cell.* It provides a great *in situ* site, a closed system. The water quality gradient up the system could be monitored (although there would be no true control because each cell is influenced by water from upstream).

8. **What initiatives (and who is doing them) are underway to examine fish habitat compensation and restoration activities?**

- *BHP Billiton has the Panda Diversion Channel; De Beers has the lake trout spawning reef at Snap Lake.*

9. **Is collaboration with industry on monitoring/research ventures mutually profitable, and are there opportunities to further such co-operation?**

- Opportunities exist with Diavik's lake and stream enhancement work on East Island. Diavik will be doing compensation projects and DFO will be involved. The company has submitted plans for stream restoration.

- Science input is needed. Diavik is willing to cooperate with us, we just need the tools, such as:

  A monitoring for success guide, and a standard habitat assessment guide (how to focus assessment of habitat to get the right outputs).

  There is also a need for standard habitat assessment protocols. For example, a NNL procedures manual: what is rearing habitat/spawning habitat; impacts to lake; restoration on stream; various approaches to weighting, and when each is appropriate.

  We do not always know in what way the habitat is important; we do not completely understand how it is used; so we do not have lake compensation examples to learn from to compensate for its loss. Unless we have a multi-faceted approach of flow dynamics, etc., we do not know where to place compensation habitat because water spirals as it flows and creates upwelling, etc.

  We would like input on Nero-Nema stream at BHPB site – adding gravel substrate for grayling spawning at Ekati. The company would provide us with flow, velocity, depth and other data.

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1. Is there a formal or informal decision-making process whereby habitat managers are able to assess impacts on fish and their habitat?

- In Alberta, DFO is responsible for fish habitat and the Province is responsible for the management of the fishery. The habitat is managed in accordance with fishery values – DFO works closely with Alberta Sustainable Resources Development in achieving both the provincial fishery goals and DFO's objective of no net loss of productive capacity of fish habitat.

- The Alberta Oil Sands (AOS) mine projects require both federal and provincial environmental assessment reviews. These are undertaken jointly in accordance with the Canada-Alberta Agreement for Environmental Assessment Co-operation.

- The Environmental Impact Assessment (EIA) report is written by the proponent subject to a Terms of Reference that, although issued by Alberta Environment, is developed jointly and meets the needs of both provincial and federal environmental assessment legislative requirements.

Depending on the answer…what is it or how is it done?

- The *Fisheries Act* section 35(2) HADD authorization triggers CEAA and the proposal for a mine always initiates an environmental assessment pursuant to the *Alberta Environmental Protection and Enhancement Act* (EPEA). In Alberta, if both jurisdictions require a formal environmental assessment, the Province takes the lead and the federal agencies that have identified a CEAA trigger or federal interest participate in a joint, coordinated review.

2. How are fish and fish habitat loss dealt with in quantitative terms? What are the species/habitats of concern?

Fish habitat

- The simplest way to estimate habitat losses is on a unit-area basis. For extensive watercourse systems this can be problematic. Quantitative habitat losses are derivations of watercourse length and width estimates. While GIS is a tool widely used to estimate stream length, there are intrinsic limitations that can reduce the accuracy. GIS inherently underestimates the length of the stream because it converts curves into straight lines. The lines are chords of the curves and will always be a biased underestimate of length. Gradient will also be biased high. Channel width and not wetted-width must be used to calculate habitat area. Without the use of correction factors to adjust watercourse length and proper width assessments undertaken, fish habitat can be significantly underestimated. *Recently, two oil sands mine developers were required to re-calculate their habitat area estimates as part of their no net loss plans (NNLPs). The revised calculations resulted in increases of up to 43% in total fish habitat area.*

- Habitat Suitability Indices Models (HSI) are more complex ways of assessing habitat quantity and quality and were proposed initially by two oil sands mine developers to estimate existing and proposed fish habitat. One company has since decided to discontinue refinement of the models and has opted to use the more simplistic habitat area method to be verified by long-term extensive and comprehensive monitoring programs. The second company is pursuing the refinement of the HSI models it has developed for its project and will verify them with long-term monitoring. Two primary concerns arose as a result of our initial review of the HSI models in the draft NNLPs:

  a) Validity of limiting variables for use in the HSI models, whether from published sources or newly-developed consultant models:

Examples from DFO review of draft NNLPs and HSI model predictions

- *Northern pike* $V_6 = 0.7$ *(85 days in Fort McMurray). This variable will not change because of the project and is not limiting to northern pike in the study area. It should be removed from the model as recommended by the United States Fish and Wildlife Service (USFWS).*

- *Walleye V_8=0.6 (temperature in summer = 18 °C). The model temperatures are too high for this area (mean weekly summer temperature of 21-25.5 °C is optimal). Temperature is not limiting or changing so it should be removed from the model.*
- *Brook Stickleback Lacustrine Model for rearing, juveniles and adults: for some of these small- bodied forage fish there has to be some variable that accounts for the bathymetric differences that would affect production. For example, depth for pearl dace in the spawning component of the model is considered excellent if there is water 0-2 m deep, unless the entire shoreline is a vertical drop all lakes would have some water 0-2 m deep. It would always get a rating of one and yet it is likely that some lakes are considerably better than others based on the area of shallow water that exists. Other models like the perch model take this into consideration as littoral area is considered important for this species production. This type of variable or lake stratification should be added to these lacustrine models.*

b) The absolute value of the variable inserted into the HSI model:

Examples from DFO review of draft NNLPs and HSI model predictions

- *Walleye – V_9=0.05 (temperature in spring = 9.3 to 10 °C). Actually, this is a mean for late spring/early summer and not just spring.*
- *Pearl Dace Riverine Habitat Suitability Model implies that DO < 5.0 would preclude any pearl dace from using this habitat.*
- *Arctic grayling - V_5 = 0.8 (average velocity = 0.33 m/s in spawning and riffle areas) is incorrect - 0.33 m/s would be a 1.0 suitability according to the model.*
- *The newly-developed consultant-derived lacustrine models have a tendency to always result in an HSI of >0.5 because few of the variables result in a score <0.5, regardless of habitat values. The ones that do are almost entirely related to dissolved oxygen, which is rarely limiting in the lake. This is in direct contrast to the consultant-derived riverine models for the same species. The result is a systematic bias favoring the compensation lake over existing habitat.*

Unlike Habitat Replacement

- Due to a lack of suitable on-site or off-site riverine compensation opportunities in the oil sands region, developers have proposed the replacement of stream habitat with lacustrine habitat. One proposal involves the loss of 130 km of stream habitat, which is to be replaced with a 70-ha lake.

Fish species

Examples from DFO review of draft NNLPs and HSI model predictions:

- *Note the variable presence of pearl dace, brook stickleback and fathead minnow in successive reaches. HSIs vary from 0-1.0. An incorrect velocity variable has resulted in the removal of these fish from reaches that one would naturally assume them to be present in.*

- *In addition to the KIR species, other fish species known or believed to reside in specific watercourses were included in the habitat availability assessment. Excluding species known to use the water body will reduce the total number of habitat units for that water body.*

- *While not specifically referenced in the NNLP review, there is a concern that some rare species have not been acknowledged as potentially present. There is no reason, based on the existing habitat and known ranges, to assume that species such as northern redbelly dace, finescale dace, spoonhead sculpin, logperch and brassy minnow will be absent.*

3. How are cumulative impacts addressed? Is there concern at the fish population level, the lake and/or watershed level?

- Pursuant to the *Fisheries Act* (FA) and the *Canadian Environmental Assessment Act* (CEAA) all impacts are examined from a project-specific perspective. However, it is impossible to truly address cumulative effects with this approach.

- AOS developers rely heavily on models to predict the long-term cumulative effects. Hydrologic simulation program FORTRAN (HSPF) is a model that has undergone extensive refinement by Golder Associates for the purposes of making predictions related to the hydrological effects of individual AOS projects.

- CEMA – *Muskeg River Watershed Integrity Task Group is using the Muskeg River Watershed as an analog study area in order to try and increase the understanding of the cumulative effects of developments on watersheds.*

- DFO identified the uncertainty and the potential significance of cumulative effects, as a result of two recent AOS projects applications, to be great enough to request a joint panel review; monitoring was the primary method recommended by the Panel to address these concerns.

4. What knowledge gaps exist and how is this dealt with in decision making?

- There are no DFO policies that guide practitioners in assessing the value of habitat.

- We are using Habitat Units as a surrogate for productive capacity. Is that appropriate?

- What performance measures can be used to evaluate compensation success and ecosystem integrity?

- On projects of the magnitude proposed in the AOS, the unknown contribution of non-sport fish cannot be discounted, nor can it be accurately evaluated based on current information. We find that non-sport or forage fish are often the most widely-distributed species. We do not know what ratios (sport fish to forage fish) are appropriate to ensure that the prey base is adequate for the sport fish.

- What is the impact of losing habitats provided by headwaters?
- EIAs conducted in support of AOS applications are based on a limited baseline sampling period (~2 years). Modeling is necessary to account for seasonal and annual natural variation (*for example, the recent sampling efforts for two mine projects were undertaken during a very dry period. These conditions are not representative of the habitat and fish that could be expected during wetter periods*). Long-term predictions must be made that incorporate landscape differences, flow changes and climate change – to name a few.
- We do not understand the needs of the life stages of the fish species, the site-specific populations, and species assemblages well enough to make scientifically-sound decisions on the significance of existing habitat features and sites; need to be specific, need to verify the assumptions we use on fish use. The forage fish models are based on very little data and no field verification.
- The "published" HSI models produced by the USFWS and used without modification have resulted in poor outcomes. These models need to be verified or better models need to be developed for northern-Canadian conditions.
- What is the link between trophic levels – i.e. forage vs. sport? We need to maintain these linkages in the replacement habitat and also need to confirm whether the fish we are interested in represent the trophic level we need and take into consideration their life stages
- We need to define our information needs in terms of trophic interactions and habitat requirements of the life stages themselves.
- Ground water-surface water interaction.
- Contaminant export and impact on surface waters.
- How can we design monitoring programs that will detect changes in the fish populations/behavior in the Athabasca River as a result of development? Are there surrogate predictors that are measurable and that can be included in monitoring plans?

5. How is uncertainty incorporated into the decision-making process regarding compensation?

- 2:1 habitat replacement ratio was selected arbitrarily for the AOS projects based on the assumption that the habitat in the affected regions was not considered critical, and there is potential for limited on-site fish habitat compensation. We have no record to determine if 2:1 is adequate.

- The fish habitat losses in existing oil sands mines have not been extensive. Existing projects have sometimes incorporated off-site compensation requirements to offset habitat losses (i.e. installation of a culvert to re-establish fish passage in an area outside the region).

- Monitoring is the primary tool to increase certainty related to the success of mitigation and compensation.

- In the AOS region, end pit lakes are not considered compensation because it is uncertain when or if they will be able to support viable biotic communities.

6. **How is habitat restored in the northern locations of Alberta? What are the pros and cons? Are there case studies (success and failure)?**

- There are no completed oil sands projects yet, so compensation success cannot yet be evaluated. Various mitigation measures are available to address surface water contamination. Process water is segregated from runoff water. Oil sands developments are so large they can be seen from outer space. Stakeholders are not enthusiastic about off-site compensation.

7. **What initiatives (and who is doing them) are underway to fill gaps in knowledge and improve decision making over damage to fish and their habitat?**

- The oil sands companies in co-operation with academic institutions are undertaking research in the region.

- CEMA and CONRAD are sponsoring research on reclamation and wetland recovery.

- Prairies Area HM has been pressing for a regional review of the oil sands development issue. Mine dewatering is a significant issue as is use of groundwater and surface water which relates to in-stream flow concerns for fish.

- CEMA; http://www.cemaonline.ca/about.htm
- CONRAD; http://www.conrad.ab.ca/yildirim/index.html
- CANMET; http://www.cbsc.org/alberta
- Alberta Research Council; http://www.arc.ab.ca/corp/History.asp
- IFN initiatives both within and outside the scope of CEMA

8. **What initiatives (and who is doing them) are underway to examine fish habitat compensation and restoration activities?**

- DFO regional office has contracted work to several hydrologists (hydrological modeler, stream hydrologists) and to a fish biologist to assist in interpreting information provided in support of AOS applications. These reviewers have also been requested to offer a critical analysis of the adequacy of what is proposed and recommendations for improvement.

- The proponents will be required to monitor fish populations in compensation habitat. The results of the monitoring will determine the effectiveness of the compensation.

9. Is collaboration with industry on monitoring/research ventures mutually profitable, and are there opportunities to further such co-operation?

- Collaboration is advantageous to all. The regional initiatives, such as CEMA and RAMP are structured to meet the needs of regulators, stakeholders and industry alike.

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1. Is there a formal or informal decision-making process whereby habitat managers are able to assess impacts on fish and their habitat? Depending on the answer...what is it or how is it done?

- We generally follow the HADD decision framework as outlined in 1998 document Framework for the Determination and Authorization of HADD of Fish Habitat.

- The first step is to determine if some component (construction, operation, etc.) of a proposed project could impact fish or fish habitat (steps 1 and 2 of the decision framework).

- Second step is to determine if the impacts can be mitigated. A variety of factors are taken into consideration during this step such as timing of the works, will there be an infilling of habitat, will the habitat be harmfully altered (removal of aquatic vegetation, simplification of habitat through removal of cover or changes to the substrate).

- Third step. If the project will result in a HADD it is then determined if the HADD should be authorized. Factors considered at this stage include: the availability of the habitat within the ecosystem (is the impacted habitat limiting), the area of habitat that is being impacted, the fish community present in the ecosystem (forage fish, game fish), the utilization of the habitat (i.e. spawning, rearing, feeding, etc.), and available options for compensation.

- As part of the review process, the possible impacts of the components of the project are considered in relation to a number of sections of the *Fisheries Act*. The relevant sections include:

    - Section 20 – will some component or phase of the project affect the passage of fish?

- Section 22 – will some component or phase of the project affect downstream flows?
- Section 30 – will water be withdrawn so that a screen will be needed on the intake to prevent the impingement or entrainment of fish?
- Section 32 – will some component or phase of the project cause the destruction of fish?
- Section 35 – will habitat be harmfully altered, disrupted, or destroyed?
- Section 36(3) – will some component or phase of the project potentially result in the release of a deleterious substance into fish habitat?

- *The DFO office in Prince Albert participated in a joint (Provincial-Federal) review of a proposal by Claude Resources Inc. to expand its Tailings Management Facilities (TMF) at the Seabee Gold Mine in Saskatchewan (approximately 120 km NE of Lac La Ronge). A small (surface area approximately 16.8 ha) headwater lake, locally known as Triangle Lake, was proposed as the preferred site of the new TMF. The proposed TMF would replace the present East Lake TMF which was reaching its full design capacity. Expansion of the East Lake TMF was considered as an option, but there were concerns regarding the increased risk of the failure of the containment dams if they were increased in size to allow for more tailings to be put in the present TMF.*

- A habitat compensation agreement between Saskatchewan Environment, DFO and Claude Resources for the East Lake TMF was signed in 1992.

  Claude Resources began construction of a reef for lake trout in a lake (Porky Lake) near the mine site. The reef was monitored in the fall of 1992 for spawning by lake trout. No lake trout eggs were found and it was recommended that additional rock be added to expand the reef. However, no additional rock was added to the reef.

- *It should be noted that there was no financial guarantee incorporated into the Habitat Compensation Agreement. The reef was surveyed again in 2001 for lake trout spawning. No eggs were found on the reef, but they were collected at a number of reference locations.*

- *During the review process, it was difficult finding suitable compensation for the destruction of Triangle Lake. The construction of another spawning reef for lake trout or of a pike spawning marsh in the general area, which is relatively pristine, was not considered to be a suitable compensation option.*

- These northern lakes are oligotrophic so their productivity will be limited by the availability of nutrients and it is not clear if spawning habitat is a limiting factor.

- *Staff from Saskatchewan Environment were consulted in regards to possible habitat compensation options. While a number of options were presented they were determined to be unsuitable as they were either outside of the watershed in which Triangle Lake is located or the options were inadequate (i.e. garbage cleanup along shoreline of a nearby lake).*

- *It was decided to defer compensation for the destruction of Triangle Lake, but that a financial guarantee would be put in place as part of the agreement. Triangle Lake and East Lake are of similar surface area and contain(ed) similar fish assemblages. Therefore, the cost for constructing another lake trout spawning shoal was calculated. This was then used to determine the monetary value of a financial guarantee for the new habitat compensation agreement.*

- *Factors considered in calculating the cost estimate included the costs for constructing the reef and for a monitoring program to determine the utilization of the reef for spawning.*

2. **How are fish and fish habitat loss dealt with in quantitative terms? What are the species [illegible] habitats of concern?**

- The amounts (calculated by area) of fish habitat that are being harmfully altered, disrupted or destroyed are quantified during the review process. These amounts are then identified in the authorization of the HADD.

- Primary focus in Saskatchewan is compensating for losses of fish habitat that may affect game fish populations.

- Compensation for the HADD of forage fish habitat has generally not been required.

3. **How are cumulative impacts addressed? Is there concern at the fish population level, the lake and/or watershed level?**

- This aspect of habitat loss has not been addressed within Saskatchewan.

- I suggest using a hierarchical approach beginning at the scale of the major watersheds that have been identified by Environment Canada for the stream-flow monitoring network. The information on habitat losses from authorizations and gains from compensation would be input into a GIS database. This system would then be subdivided into smaller watersheds.

4. **What knowledge gaps exist and how is this dealt with in decision making?**

- Habitat information for fish species in Saskatchewan.

- Information is available in the various Habitat Suitability Indices that have been produced by the U.S. Fish and Wildlife Service but these indices are quite general. Specific habitat requirements for Saskatchewan fish species have not been well documented.

- In addition habitat maps have been produced for a few lakes in Saskatchewan but this program to the best of my knowledge has been discontinued. This habitat mapping should then be followed up by studies to determine how the habitat is being utilized by fish for spawning, rearing, feeding, etc.

- Presently using the general HSI to determine the importance of fish habitat and supplement with site-specific data when available.

5. **How is uncertainty incorporated into the decision-making process regarding compensation?**

- Generally account for uncertainty by doubling or tripling the size of the compensation area in relation to the amount of habitat that has been impacted by the project (e.g. for 100 m² there is 300 m² of compensation habitat created or restored).

6. **How is habitat restored in the northern locations such as Yukon/Alberta/Northwest Territories/Nunavut –as appropriate re industry? What are the pros and cons? Are there case studies (success and failure)?**

See comments below.

7. **What initiatives (and who is doing them) are underway to fill gaps in knowledge and improve decision making over damage to fish and their habitat?**

- As part of monitoring programs for a number of fish habitat compensation projects at the uranium mines, reference sites are also being monitored. This will allow for a comparison of the reference sites with the compensation sites.

- The gathering of information from the reference sites has thus provided habitat utilization information for some native fish species (lake trout, northern pike, and lake whitefish) in Saskatchewan. The monitoring programs have been conducted by environmental consultants hired by the uranium companies.

A habitat study was conducted on a stream in central Saskatchewan to determine what factors may have been responsible for a reduction in a walleye spawning run. This was done as part of a habitat compensation agreement for the destruction of a lake at a gold mine.

- There is also a lot of information that has been gathered from various Environmental Impact Statements that should be documented in a GIS database. This would include: identification of spawning areas, utilization of the spawning areas, and dates for when spawning activity has been taking place.

8. **What initiatives (and who is doing them) are underway to examine fish habitat compensation and restoration activities?**

- The operations of most of the uranium mines in northern Saskatchewan have had impacts on fish habitat that have required habitat compensation agreements. As part of these agreements, monitoring programs have been conducted to determine the effectiveness of the habitat compensation. These monitoring programs have not been completed at this time so the final evaluations are still pending.

- *For the Rabbit Lake mine monitoring of the pike spawning marshes and one of the lake whitefish spawning shoals was conducted two years after the construction of these habitat compensation sites were completed. A second monitoring survey was conducted two years later. A third survey is still planned for the lake whitefish spawning shoals.*

  For the McLean Lake mine a baseline survey (prior to construction) of the compensation and reference sites was conducted in 1998. Construction of the compensation sites was to take place in January of 1999, but it was delayed by a year. Monitoring of the compensation and reference sites was then planned to take place every three years over a nine-year period.

9. Is collaboration with industry on monitoring/research ventures mutually profitable, and are there opportunities to further such co-operation?

- This has not been readily pursued to any great extent in Saskatchewan. However, Saskatchewan Power Corporation will be participating in an in-stream flow needs study on the Saskatchewan River downstream of the E. B. Campbell Dam.

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1. Is there a formal or informal decision-making process whereby habitat managers are able to assess impacts on fish and their habitat?
Depending on the answer...what is it or how is it done?

- There is no formal decision making process that we are aware of specific to the Eastern Arctic. The only formal documents that are used are national documents such as the Decision Framework for Determination of HADD and the Policy. Otherwise it seems to be a much more informal decision based on information provided by the proponent and the expertise of the biologist reviewing the file.

2. How are fish and fish habitat loss dealt with in quantitative terms? What are the species/habitats of concern?

- Both Derrick and I have limited knowledge of this issue to date however, for the Doris North Project a modified Habitat Evaluation Procedure was used to determine the number of Habitat Units in the lake proposed for destruction. To rationalize its proposal, the same procedure was used to evaluate the proposed compensation areas such that losses and gains could be compared.

- Species of concern in the Eastern Arctic are primarily related to subsistence fisheries (and less often recreational fisheries) for Arctic charr, Arctic grayling, lake trout, and whitefish. These are the fisheries most commonly impacted by whole lake loss proposals. However, within the Eastern Arctic Area there are also commercial fisheries for turbot, Arctic charr, shrimp with additional work being done to assess potential fisheries for crab and clams. Commercial fisheries are predominately marine in nature and to date there seems to be little development work affecting habitat for these species. Impacts to commercial fisheries may become a larger issue for habitat staff as development in the north and the number of commercial operations increases. Habitats of concern are typically spawning, nursery, rearing, migration and over-wintering habitat.

3. How are cumulative impacts addressed? Is there concern at the fish population level, the lake and/or watershed level?

- Cumulative effects are considered as part of CEAA and there are concerns at the fish population level and lake/watershed level however, given our limited time in the north I do not think Derrick and I could comment at this point as to how effectively they are being addressed.

4. What knowledge gaps exist and how is this dealt with in decision making?

- There are a number of knowledge gaps at this point. Primarily these relate to a lack of information on biology and habitat requirements for species in the Eastern Arctic. We predominantly rely on information that has been gathered in the south or in the Western Arctic along with information provided by the proponent in support of its application, to make decisions.

5. How is uncertainty incorporated into the decision making process regarding compensation?

6. How is habitat restored in the northern locations such as Yukon/Alberta/Northwest Territories/Nunavut – as appropriate re industry)? What are the pros and cons? Are there case studies (successes and failures)?

- Neither Derrick nor I have seen restoration efforts given our limited time in the north. We might be able to shed more light on this once we have spent a few more months here.

7. What initiatives (and who is doing them) are underway to fill gaps in knowledge and improve decision making over damage to fish and their habitat?

- To our knowledge there are no initiatives underway.

8. **What initiatives (and who is doing them) are underway to examine fish habitat compensation and restoration activities?**

- There are none that we are aware of.

9. **Is collaboration with industry on monitoring/research ventures mutually profitable, and are there opportunities to further such co-operation?**

- We have not heard of this happening in the Eastern Arctic.

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1. **Is there a formal or informal decision-making process whereby habitat managers are able to assess impacts on fish and their habitat?**
   Depending on the answer...what is it or how is it done?

- In Ontario, staff reference DFO publications such as the Decision Framework for the Determination and Authorization of Harmful Alteration, Disruption or Destruction of Fish Habitat (DFO 1998) and the 1986 Policy for the Management of Fish Habitat (DFO 1986) during the decision-making process.

- We consult with the Ontario Ministry of Natural Resources. They have extensive databases and corporate knowledge on what the potential impacts to the fishery will be from such large-scale habitat losses.

- OGLA staff also seek advice from DFO scientists (primarily from CCIW and FWI, but also other DFO scientists, and academia where possible expertise exists), senior habitat managers, Environment Canada, and Ontario Ministry of Environment. Ontario Ministry of Northern Development and Mines is also available to project reviewers.

2. **How are fish and fish habitat loss dealt with in quantitative terms? What are the species/habitats of concern?**

- The 1986 Policy for the Management of Fish Habitat is referred to while reviewing files. Section 5.1 (Hierarchy of Preferences) discusses the application of the no net loss principle by requesting like-for-like habitat replacement when redesign or relocation is not possible.

- Habitats specific to high water flows or ground water upwelling (spawning) have proven to be a concern as many mining projects involve surface water flow and/or ground water flow alteration.

- Habitats supporting traditional fisheries are often a concern with mine development.

- Staff must consider the loss of habitat to the specific water body and how that will affect the existing fishery. Where the entire water body is proposed to be removed, then staff will need to look at the loss of that water body (e.g. a lake within a watershed) and determine if the loss of that lake will result in a loss of habitat that is critical for the fish species within entire watershed or if the loss of habitat will result in only in the loss of direct and indirect habitat at the site only and the fish species/stock can still continue to exist within the watershed or sub-watershed. Compensation and project design advice are tailored against that first analysis.

- *For example, if a whole lake is removed from a watershed where 10 other lakes exist and the lake is replaced by a bypass stream for operational purposes and the principle species of concern is brook trout which will continue to survive and migrate throughout the watershed in the remaining streams, channels and 9 lakes, then the decisions in relation to the Habitat Policy, the Fisheries Act and the Conservation and Protection Guidelines (Fisheries and Oceans Canada 1998) are applied differently than where critical habitat is involved.*

3. **How are cumulative impacts addressed? Is there concern at the fish population level, the lake and/or watershed level?**

- Cumulative impacts are addressed under CEAA reviews as a result of the section 35(2) trigger.

- In the most basic sense, if a proponent is in a remote area and is proposing to take one whole lake from the area, there is no cumulative impact.

- A cumulative impact can only occur if another company or the same proponent comes into the watershed and wants to take out another lake or connecting channel to the lakes or take the other part of the lake. The potential for such an event is to be identified as part of the environmental assessment.

- Typically the decision to authorize one or more lakes whether cumulative or not will be based on the specific circumstances of the proposal…see the example above.

- OGLA staff are to consider what the impact of the project is on the fisheries community before making a decision to authorize or not.

- Although not explicitly required under the DFO policies and procedures, there is an inherent decision-making process which does contemplate potential cumulative effects before reaching the decision to authorize or not. If there is a decision to authorize, CEAA is triggered and then OGLA staff will specifically require the proponent to address cumulative impacts.

- Depending on the location of the project (headwaters, size of watershed basin) and amount of related/unrelated activity found within the site, there may be concern on all levels.

4. What knowledge gaps exist and how is this dealt with in decision making?

- Information on historical and current fish/fish habitat data, mining technology and quantifying impacts associated with lake/large area losses and developing suitable compensation represent knowledge gaps.

- Provincial agencies such as Ontario Ministry of Natural Resources (OMNR), Ministry of Environment and Ministry of Northern Development and Mines are used as resources in the decision-making process.

- Findings and recommendations from past mining projects have been used in making *Fisheries Act* and policy (chapter 3 and 4) decisions as well as in developing suitable compensation.

- *For instance, in the example above where one lake out of 10 brook trout lakes is taken out of a watershed, there is arguably a 10 percent reduction in the fisheries resource for the watershed which may be acceptable within the fisheries resource management objectives for the area (OMNR) with some suitable offsetting compensation which achieves the Policy objective of a net gain.*

5. How is uncertainty incorporated into the decision-making process regarding compensation?

- This question is unclear. I expect the question really is how do DFO staff make a decision when it is uncertain if the compensation will offset the potential loss of the fisheries resource.

- DFO staff will request as much information from the proponent as required before making a decision. If information cannot be provided it is left to the reviewer, through adaptive management, to make a decision on whether or not compensation meets policy requirements.

- As mining is becoming increasingly feasible in northern Ontario and relatively little information is available on proven compensation methods, there is always a level of uncertainty involved in mining project reviews.

- Much of the uncertainty that staff have in relation to this question is that DFO and most resource agencies do not have a good tool by which to define what the existing fishery is, and then a good tool to measure how much of an impact will be felt in that fishery if a part is removed. And then further, we have no good tools to measure the effectiveness of the compensation to offset the loss of something for which we had no definitive number for in the first place.

- This circumstance gets more uncertain when a compensation or mitigation approach is proposed which is new or conceptual and unproven.

- Typically, OGLA staff continue to rely on the simplest approach that has been used traditionally to request information and compensation approaches on an area lost to area replaced basis according to the Compensation Directive and hierarchy of preferences set out in that directive and the Habitat Policy.

- These decisions are strongly influenced by the individual's ability to take a common-sense approach, which attempts to make the decision in respect of what the impacts to the fish will be rather than the perception of others.

- On large decisions where the perception may outweigh the actual impact professional judgment by the individual in concert with getting advice from other experts in the area and in the fishery help to offset the uncertainty.

6. **How is habitat restored in the northern locations such as Yukon/Alberta/Northwest Territories/Nunavut – as appropriate re industry? What are the pros and cons? Are there case studies (success and failure)?**

7. **What initiatives (and who is doing them) are underway to fill gaps in knowledge and improve decision making over damage to fish and their habitat?**

- This question is pretty general. If it is specific to what initiatives are underway to improve decisions on the HADD associated with whole lake or large-scale destruction of habitat in northern and remote areas and what the impacts of these are to the fisheries at the individual and community level, the answer can be more specific.

- In Ontario very little research has been done recently which is directly related to loss of habitat and impacts to fish at the lake and watershed level.

- A considerable amount of research has been conducted in areas such as Cornwallis and Little Cornwallis Islands on impact from mining on lakes. *The work by Dr. Welch and colleagues at Saqvaqjuac on the west coast of Hudson Bay provided a considerable amount of information on productive capacity, nutrient, and fish community and limnological information which is still useful.*

- OGLA organized and hosted a workshop in Edmonton last December with DFO staff particularly interested in diamond mining project impacts to fish and fish habitat. A manuscript report is being prepared such that the results of that workshop will be more generally available and referenced (Eddy and DeBruyn in preptn). A number of similar workshops were convened by other resource management agencies however the reports from them have not been formally prepared or distributed. This would be helpful to the DFO staff.

  OGLA has established under the Habitat Operations Council, a Mining Task Group. Its purpose is to establish a better understanding of what DFO's role in Ontario is in respect of the mining industry within the context of the other federal and provincial resource management agencies.

- There are a number of provincial and federal policies, and legislation and regulations which come into play for staff within this provincial setting.

- To set OGLA programs in the best position within the auspices of chapters 3 and 4 of the Habitat Policy and work towards sustainable development with provincial agencies and proponents from different mining and exploration sectors, the Task Group was established to begin building that information-assembly process. This is being formed within OGLA to develop tools for staff to deal with information gaps and to better able staff to manage mining referrals.

- Great Lakes Laboratory for Fisheries and Aquatic Sciences (GLLFAS) and Freshwater Institute (FWI) researchers have worked over the years, and are currently working on, a number of areas to provide information to habitat staff which may be useful to those projects in the north. *Whole lake drawdown, flow manipulation, macrophyte community relationships with esocids are examples [northern pike and muskellunge, along with pickerel, are sometimes referred to as esocids; they belong to the pike family, whose technical name is Esocidae].*

- Proponents collect baseline data for their project impact statements. Often these data sets are one-off items which do not account for natural and inter-annual variability and often are collected in a manner which does not represent seasonality. Past proponents have provided and continue to provide information as required in the post-project monitoring requirements of an authorization. This may be valuable to DFO staff reviewing future projects similar in nature.

- The habitat programs at the area, regional and national level do not have a substantive mechanism by which to collect, archive and make available data collected for project-specific purposes which may be useful to other assessors within the region or nationally.

- A national subject matter expert would be a start to achieve this. The Habitat Referral Tracking System (HRTS) allows some ability to search out staff who may be involved in similar types of projects or areas but it does not provide more than the phone number of whom to call.

- OGLA staff continue to consult with Provincial government agencies which may be assessing local water bodies through population and habitat index studies.

8. What initiatives (and who is doing them) are underway to examine fish habitat compensation and restoration activities?

- Great Lakes Laboratory for Fisheries and Aquatic Sciences (GLLFAS) has undertaken lake habitat manipulation research.
- Habitat biologists from Pacific Region have conducted some regional studies on the effectiveness of compensation.
- OGLA staff attempt to ascertain that compensation was implemented as required under the authorization on approximately 10 percent or more of their projects.
- OGLA Program Services has conducted a QA/QC program on monitoring and compliance.
- Province and local fish and game groups participating in restoration projects (Community Fisheries and Wildlife Involvement Program, CFWIP, Junction Creek, Blue Jay Creek, Manitou River).

9. Is collaboration with industry on monitoring/research ventures mutually profitable, and are there opportunities to further such co-operation?

- Yes. A number of science for habitat workshops have been held with other agencies and with industry.
- The objectives and the manner in which monitoring and research are conducted must be standardized to a certain level to be of much utility beyond the project-specific application.
- Science and habitat staff will need to develop approaches where pre-impact sampling methods are standardized as well as for post-impact studies.
- The data from these studies should be archived in a manner which makes them more useable. Sector associations could provide a role in this regard, government-established and maintained desks for subject mater experts would also be mutually beneficial to both industry and national program staff.
- *As an example, OGLA is presently collaborating with both the hydro and forestry industries.*

- Senior DFO Management sees the Canadian Electricity Association MOU as the way DFO should be doing business in the future.

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1. **Is there a formal or informal decision-making process whereby habitat managers are able to assess impacts on fish and their habitat?**

Depending on the answer…what is it or how is it done?

- The decision-making process is the same as for any large-scale project:

- An analysis is performed in which impacts are assessed in terms of habitat productive capacity based on the size and functions of the habitats affected for the various species present.

- The flows left in watercourses and any structure that impedes the free passage of fish are also taken into account.

- One or several analysts are assigned to perform this analysis. Complex issues are discussed in team meetings or with managers in the Region or at headquarters.

- Managers are notified of the possible impacts of a project with a view to decision making. Generally, this fits into the environmental assessment context under the *Canadian Environmental Assessment Act* (CEAA), and a report (screening or comprehensive study) is prepared with recommendations for mitigation measures.

- An assessment is conducted early in the process to determine whether the project must be referred to a public review panel.

2. **How are fish and fish habitat loss dealt with in quantitative terms? What are the species/habitats of concern?**

- To assess large-area habitat losses (entire lakes), the Bradbury, Power and Roberge method is used, cf. Standard Methods Guide for the classification/quantification of lacustrine habitat in Newfoundland and Labrador, DFO, NL, 60 p. Quebec habitats that have ongoing mining operations are very similar to those covered in this guide.

- This method is also used (adapted) to determine the productive capacity of lakes currently being used as tailings impoundment areas (TIAs) and in respect of which an application has been filed for listing in Schedule 2 to the Metal Mining Effluent Regulations (MMER).

3. **How are cumulative impacts addressed? Is there concern at the fish population level, the lake and/or watershed level?**

- Mining has considerable impacts at all of these levels: at the fish population, lake and watershed level.

- Some regions of Quebec are being mined intensively. *For example, the combined regions of Abitibi-Témiscamingue and Nord-du-Québec contain more than half the surface area occupied by known tailings impoundment areas in Quebec (i.e. approximately 420 impoundment areas covering 8,000 hectares).*

- The vast majority of mining developments commenced operating a number of years ago and DFO was not involved in assessing the impact of these projects on fish habitat. We therefore do not have extensive experience in assessing the cumulative effects of these types of projects.

- With the recent passage of the MMER, DFO has been assigned a number of files whose cumulative impact must be considered. We intend to assess them at the watershed level, i.e. taking a "macro" approach to the impacts involved.

- Cumulative impact assessment on a narrower scale would require a tremendous amount of energy and would involve a great deal of uncertainty due to gaps in knowledge.

- Impact assessment at the watershed level instead of the fish population level will reduce the effort required to assess impacts, while taking into account the other issues present in the watersheds and maintaining a solid notion of the potential long-term impacts of mining.

4. **What knowledge gaps exist and how is this dealt with in decision making?**

- We lack knowledge of:
    - the productive capacity of the disturbed sites (productivity of the lakes already being used as TIAs);

- the impacts of severed water links, of earthworks and of the drying out of numerous watercourses in a given watershed;
- the productivity of northern habitats;
- the restoration capacity of sites; and
- the cumulative impacts of mining.

- The Science Sector in the Quebec Region conducts ocean science research, but it has no expertise in and does not conduct any research on freshwater ecosystems.

- The Habitat Management Program consequently cannot take advantage of research results to fill knowledge gaps in connection with mining development.

- Conversely, DFO often requires proponents to monitor the impacts of their projects and the success of the habitat compensation measures they are required to implement. This helps to generate new information, but the usefulness of this new information in eliminating knowledge gaps remains limited.

5. **How is uncertainty incorporated into the decision-making process regarding compensation?**

- Uncertainty is incorporated into the decision-making process by applying precautionary principles and professional judgement (to the best of your knowledge).

- Follow ups may be required to verify impact assessments and eventually apply corrective measures.

6. **How is habitat restored in the northern locations such as Yukon/Alberta/Northwest Territories/Nunavut – as appropriate re industry? What are the pros and cons? Are there case studies (success and failure)?**

- We have no experience in restoring mining sites.

- In Quebec, however, the provincial Department of Natural Resources has collaborated in the restoration of several sites.

- *In 2002, of the 14,904 hectares used for the disposal of mine tailings, about 3,000 hectares were rehabilitated and 960 were partially restored. For information on provincial government regulations in Quebec see its Regulatory Provisions website http://www.mrnfp.gouv.qc.ca/english/mines/environment/environment-provisions.jsp*

- *You may also wish to consult Quebec's provincial Rehabilitation Guide at this URL: http://www.mrnfp.gouv.qc.ca/english/mines/environment/environment-guide.jsp*

7. **What initiatives (and who is doing them) are underway to fill gaps in knowledge and improve decision making over damage to fish and their habitat?**

See the reply to question 4 above.

- To our knowledge, no specific initiatives are underway in Quebec to fill knowledge gaps, other than requests for information and follow ups made to proponents.

  With regard to decision making, refer to question 1.

8. **What initiatives (and who is doing them) are underway to examine fish habitat compensation and restoration activities?**

- DFO is reviewing existing mining projects for the purposes of the MMER with regard to their impact on fish habitat and compensation.

- For new projects, current DFO policies are applied. These reviews are being conducted by fish habitat management personnel in the Quebec Region of DFO, in collaboration with Environment Canada, which is responsible for administering and enforcing section 36 of the *Fisheries Act,* including the MMER.

- DFO has no site restoration initiatives in this Region.

9. **Is collaboration with industry on monitoring/research ventures mutually profitable, and are there opportunities to further such co-operation?**

- We have no experience in that area.

- In the Quebec Region, a DFO-industry partnership for research would certainly be desirable. However, as explained in the response to question 4, the Quebec Region performs no freshwater research; consequently, such a partnership would be difficult to establish.

- For the same reason and because of a lack of financial resources, the Quebec Region of DFO prefers to have industry do its own impact monitoring pursuant to the Region's recommendations.

Newfoundland and Labrador Region:

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1. **Is there a formal or informal decision-making process whereby habitat managers are able to assess impacts on fish and their habitat? Depending on the answer...what is it or how is it done?**

- Yes, there is an informal decision-making process whereby Habitat Management (HM) staff conduct habitat assessments.

- Information on the habitat requirements/preferences of various life stages of freshwater and anadromous/catadromous fishes occurring throughout Newfoundland and Labrador was compiled by HM staff and published as a DFO Manuscript Report entitled "Life history characteristics of freshwater and anadromous/catadromous fishes occurring throughout Newfoundland and Labrador, referred to as Bradbury et al. (1999).

- HM staff in the Newfoundland and Labrador (NL) Region then developed a guideline entitled "Standard Methods Guide for the classification/quantification of lacustrine habitat in Newfoundland and Labrador" referred to as Bradbury et al. (2001). This guideline provides a standardized approach when assessing habitat impacts (i.e. harmful alteration, disruption or destruction of fish habitat) resulting from various developments and was originally inspired by some of the preliminary work reported by Dr. C.K. Minns.

- Basically, to utilize this methodology the proponent must submit the following information on the lake, or section of lake, to be impacted:

  fish species present; substrate mapping; bathymetry; and vegetative cover. Information on various condition indices (e.g. nutrient availability, water quality parameters, lake morphometry, presence of contaminants, etc.) may also be provided as a means of reflecting fish habitat productivity.

2. **How are fish and fish habitat loss dealt with in quantitative terms? What are the species/habitats of concern?**

- The two documents referenced above are then used to classify/quantify fish habitat losses (and/or gains in the case of fish habitat compensation) in lakes and ponds. The basic underlying premise of this approach is that habitat is classified and quantified according to the extent by which it is utilized by various fish species and their different life stages.

- A key assumption is that the frequency with which a species utilizes a particular habitat provides a good indication of its importance and as such its contribution to fish productivity.

- Species of greatest concern are those that support commercial, recreational and/or Aboriginal fisheries (e.g. Atlantic salmon, Arctic charr, brook trout, lake whitefish, etc.).

- In the past, habitats of greatest concern were those providing spawning and/or rearing areas for species supporting commercial, recreational and/or Aboriginal fisheries. More recently, important over-wintering and/or summer refuge areas have also been taken into consideration for these same species.

3. **How are cumulative impacts addressed? Is there concern at the fish population level, the lake and/or watershed level?**

- When assessing impacts on lake habitats, HM staff also determine what effects, if any, they will have on species inhabiting a lake's tributary streams. A system referred to as the Beak (1980) habitat classification system is currently used by HM staff in this instance. However, this system was developed mainly for salmonids, specifically Atlantic salmon and brook trout, and is therefore limited in terms of its applicability to other, non-salmonid species.

- HM staff in the NL Region are currently developing a revised riverine habitat classification system to deal with an increased diversity of fish species.

4. **What knowledge gaps exist and how is this dealt with in decision making?**

- There is a general lack of information pertaining to the lacustrine habitat requirements of many of the fish species in Newfoundland and Labrador. Consequently, much of the information used by HM staff during decision making is based on fish habitat utilization in similar geographical areas in Canada, the United States, and other countries in north temperate locations.

- Furthermore, much of this information was derived from studies that involved sampling of specific habitats, rather than a range of habitats. Undoubtedly, some habitats (e.g. predominantly boulder habitats) which are difficult to sample with traditional gear received less attention than those for which sampling equipment is better suited. Depth of occurrence also poses a problem, as water temperature often plays a critical role in depth selection which may vary depending on size of the lake, season, and activity levels. In addition, although most of our decisions are based on physical habitat features such as water depth, substrate type, and cover being utilized by various fish species, habitat use is not solely dependent on attributes of the physical environment.

- Spatial and temporal variations in prey availability, interspecific interactions (e.g. competition and predation), and various environmental variables such as water quality may cause shifts in habitat utilization. Even the location of fish within the water column can be greatly influenced by water temperature and light intensity.

- HM staff are continuously trying to improve their knowledge on regional fish habitat utilization through various aspects of project monitoring as well as collaborative research with Science.

- Due to this general paucity of information, HM staff have adopted a precautionary approach when assessing lake impacts by trying to protect the widest possible variety of fish species, including their different life stages (i.e. species that directly or indirectly support, existing or potential, commercial, recreational, and/or Aboriginal fisheries).

5. How is uncertainty incorporated into the decision-making process regarding compensation?

- Identifying/determining fish habitat compensation options for habitat loss in lacustrine (lake/pond) environments continues to be challenging. While there is a large body of scientific information available regarding habitat creation, restoration, and enhancement in riverine systems, similar information for lacustrine systems (e.g. whole lake destruction) is limited, particularly in relation to northern environments. NL Region has compensated for partial/whole lake loss by improving and/or increasing littoral areas and/or adjacent riverine areas that are utilized by fish. Given that these projects are few, we have limited information. In addition we have frequent personal communications and discussions with various Science staff in relation to whole lake destruction and associated compensation.

- The following study had as one of its objectives the evaluation of the potential for compensation ratios for differing habitats (especially lake vs. stream). The paper was presented during the 2004 CSAS Proceedings and it should be on the CSAS website. (Clarke and Scruton 2004).

- The NL Region follows a precautionary approach to fish habitat compensation as a means to reduce the level of uncertainty associated with the success of compensation options for whole or partial lake destruction.

- *Fish habitat compensation for mining projects has included increasing the productive capacity of fish-less lakes via the transfer of fish from impacted ponds. The receiving ponds have higher lacustrine habitat equivalent units than the donor ponds, however, due to the level of uncertainty associated with this compensation option, DFO would require a higher compensation ratio than 1:1 if all available units in the receiving pond were necessary. In addition, compensation for partial lake loss has included improving and/or increasing littoral areas and/or adjacent riverine areas that are utilized by fish.*

- In addition to the above, this Region utilizes two primary data collection requirements to further reduce uncertainty associated with a compensation option. The first is a requirement for the proponent to conduct compensation baseline studies. These baseline studies are in addition to any previous studies conducted during an environmental assessment process and are typically related to specific issues and/or data gaps associated with a particular compensation option. The second requirement is for an extended compensation monitoring program. The objective of the monitoring program is to determine whether conditions of the compensation program have been met and to determine how well the new habitat is functioning as designed. Its duration is dependent on both the complexity of works to be undertaken and the species life stage requirements.

- With respect to lacustrine fish transfer programs associated with whole lake destruction, the monitoring period is usually greater than ten years.
- If monitoring reports indicate that a compensation program is not functioning as designed, this Region has required proponents to carry out modifications to the compensation program.

6. How is habitat restored in the northern locations such as Yukon/Alberta/Northwest Territories/Nunavut – as appropriate re industry? What are the pros and cons? Are there case studies (success and failure)?

- With respect to the NL Region, *the following compensation options are some examples that have been applied to mining operations in northern Labrador.*

Luce Pit Continuation of the Carol Mining Project

- *The Iron Ore Company of Canada (IOC) intends to develop and operate open pit mining facilities within the Luce Pit in western Labrador.*
- *In order to access the iron ore reserves, IOC dewatered Hakim Lake and Hakim Brook and diverted the outlet stream of White Lake around the pit. This resulted in a loss of 12.2 ha of lacustrine habitat equivalent units and approximately 45 units (1 unit = 100* m^2*) of riverine habitat.*
- *The compensation plan consists of increasing the productive capacity of White Lake (a fish-less lake) through the relocation of fish from Hakim Lake and Hakim Brook to White Lake and the creation of spawning and rearing habitat via construction of a channel at the outlet of White Lake.*
- *The plan also provides for the creation of salmonid spawning and rearing habitat at Tinto Brook, along with modifications of the Tinto Brook culvert to provide fish passage to Wabush Lake.*
- *Prior to the compensation works being undertaken, IOC was required to conduct baseline studies to ensure that White Lake was fish-less and could also maintain a viable fish population. (Baseline studies of White Lake included: a bathymetric survey, Secchi depth, substrate mapping, fish sampling program, small scale hydroacoustic surveys, benthic invertebrate, primary productivity, and water quality surveys).*
- *Compensation monitoring will be required until 2011.*

- *Preliminary results to date indicate that fish transferred from Hakim Lake have been found to be utilizing the newly-created White Lake outlet.*

Voisey's Bay Mine/Mill Project

- *The Voisey's Bay Nickel Corporation (VBNC) intends to construct and operate a nickel-copper-cobalt mine/mill in Voisey's Bay, Labrador.*

- *The potential impacts of the Project on fish and fish habitat have been identified as the loss of 58 units of riverine and 90 ha of lacustrine habitat equivalent units.*

- *To compensate for the loss of productive lacustrine and riverine fish habitat, VBNC will increase the productive capacity of Pond 61, (a fish-less lake), through the relocation of fish from Headwater Pond and the establishment of a naturally-sustaining population in Pond 61. In addition, VBNC will establish a habitat restoration program where VBNC, in consultation with the Innu Nation and the Labrador Inuit Association (LIA), will identify suitable candidate site(s) for habitat restoration within Labrador. Upon DFO's final approval of potential proposal(s), VBNC will then be required to conduct restoration and associated monitoring activities to ensure the restored habitat is functioning as designed.*

- *Compensation baseline studies were conducted to ensure that Pond 61 was fish-less and could also maintain a viable fish population. (Baseline studies of Pond 61 included: a bathymetric survey, Secchi depth, substrate mapping, fish sampling program, habitat surveys and electrofishing along its tributaries, small scale hydroacoustic surveys, benthic invertebrate, primary productivity, and water quality surveys)*

- *Compensation monitoring will be required until 2014.*

Carol Project Tailings Management Plan

- *In order to comply with the Metal Mining Effluent Regulations (MMER), IOC is proposing to construct and operate a dyke system to confine tailings on the western side of Wabush Lake, which is situated immediately west of Labrador City and north of the Town of Wabush.*

- *To compensate for the loss of productive fish habitat associated with the construction and operation of the tailings confinement dyke, IOC will create 43 ha of lacustrine habitat equivalent units along the outside face of the dyke. In addition, the company will improve the productive capacity by a minimum of 633 ha of habitat equivalent units within Wabush Lake through the confinement of tailings, consolidation of discharges, and routing of all tailings to the confinement area.*

- *Baseline compensation studies include hydroacoustic surveys, benthic invertebrate sampling and a primary productivity study. Compensation monitoring will be required until 2025.*

The pros and cons of working in northern environments are listed below:

- **Pros**

The Department can gain insight into potential compensation/restoration options by consulting with the Aboriginal community, in particular as it relates to traditional ecological knowledge (TEK).

- **Cons**

Logistical problems (e.g. gaining site access, short field season, etc.).

Climate/geomorphology of the environment (tundra, rocky coastlines, etc.).

Enhanced public scrutiny/Aboriginal issues/limited opportunities for enhancement/restoration.

To date, there have been no case studies concluded on compensation initiatives within Labrador, however, projects have or will have long-term monitoring programs and as such the Department will be able to assess the effectiveness of these compensation options as they progress.

7. What initiatives (and who is doing them) are underway to fill gaps in knowledge and improve decision making over damage to fish and their habitat?

- The following initiatives are currently being undertaken by Science in an attempt to fill knowledge gaps and improve decision making regarding impacts to fish habitat:

Evaluating habitat surrogates of productive capacity of fish habitat through linking empirical measures of biomass and total production;

Evaluating habitat use and preferences for three co-existing anadromous salmonid species in Labrador; and

Investigating the effects of varied hydro-peaking regimes on Atlantic salmon survival and habitat use during the winter.

8. What initiatives (and who is doing them) are underway to examine fish habitat compensation and restoration activities?

- In the NL Region, HM has always encouraged and promoted partnering with the Department's science community with respect to value-added research over and above existing compensation programs.

- In the past, HM has partnered/participated with the Environmental Science Section in research programs within insular Newfoundland aimed at evaluating the production characteristics of created/enhanced compensation channels.

- As well, HM has initiated a multi-year study to identify and/or evaluate possible enhancement/restoration sites throughout the province for consideration as suitable compensation options.

9. Is collaboration with industry on monitoring/research ventures mutually profitable, and are there opportunities to further such co-operation?

- With respect to monitoring activities, all proponents within the NL Region are required to conduct their own fish habitat compensation and environmental effects monitoring (EEM) programs as conditions of their *Fisheries Act* authorizations.

- These programs are reviewed by DFO prior to their implementation and once implemented all monitoring reports are provided to the Department for review and approval. As discussed previously, if monitoring reports indicate that a compensation/EEM program is not functioning as designed, this Region has required proponents to carry out modifications to the compensation plan.

- Collaboration with Industry on monitoring/research ventures would be mutually profitable. Proactive initiatives such as partnering arrangements have traditionally been effective in protecting/creating/enhancing and maintaining aquatic habitats and as such should be actively promoted.

- The Department must encourage a more cooperative and mutually-beneficial relationship between regulator and proponent.

- *One recent example of mutual collaboration was the NL Region's Fish Habitat Compensation Information Sessions. In an effort to raise industry's awareness and understanding of fish habitat compensation, the Habitat Planning and Operations Section (HPOS) of Marine Environment and Habitat Management (MEHM) held public information sessions on fish habitat compensation throughout the province in February/March 2004 to various resource sector proponents, including the mining industry.*

- *The intent of the information sessions was to increase the proponent's understanding of fish habitat compensation by providing a general overview of the key concepts of fish habitat compensation and to provide guidance to proponents with respect to their obligations associated with the development, implementation, maintenance and* *monitoring of a fish habitat compensation program. These information sessions received enthusiastic participation and positive feedback.*

- *In general, proponents were encouraged by the sense of openness and flexibility associated with habitat compensation operations and this Region's apparent practical and balanced approach with administering the compensation guidelines. As such, it is anticipated future collaboration between the Department and Industry will be greeted with the same level of co-operation.*

- In addition, MEHM also promotes value-added research being undertaken in conjunction with compensation works. To date, *two projects in insular Newfoundland (the Rose Blanche and Granite Canal Hydroelectric developments) have had research initiatives undertaken by Science staff in collaboration with MEHM. These activities are proving to be very valuable and adding much needed information regarding suitability and effectiveness of riverine compensation works.*

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Habitat compensation and assessment

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Fish Habitat Compensation – An evaluation in regard to the Habitat provisions of the *Fisheries Act.*

The comments provided herein are from workshops that were convened at the regional and national level 2003-2004. The significant points are as follows:

- Between 1986 and 2002, only 10 studies were conducted or commissioned by DFO that evaluated the performance of fish habitat compensation projects in achieving no net loss (NNL) of the productive capacity of fish habitat.

- The studies evaluated compensation projects in freshwater and marine environments.

- The majority of them were conducted in BC. Typically, evaluations were based on determinations of areas of habitat. Only 1 published report had a scientific research basis (Scruton 1996). One hundred three HADDs affected 1.14 million m^2, and the majority were associated with marine and estuarine environments. Fifty percent of the compensation projects had compensation ratios that were <1:1 ratio (habitat replaced:lost), 76% <2:1 ratio. The mean duration of post-construction monitoring required by the authorizations was 3.6 years.

- There has been little quantitative evaluation of habitat compensation, and there is a need for quantitative scientific methodologies to assess the achievement of no net loss through habitat compensation.

- A review of *Fisheries Act* authorizations issued across Canada between 1994-1997 included projects in YT, BC, MN, ON, NB, and NS.

- The HADD area affected was 420,000 m^2, compensation 1 million m^2, however the reporting of habitat gains and losses was poor.

- In most cases, assessments of HADDs and/or compensation habitats typically included areal measurements of the HADDs and compensation (i.e. no surrogates to productive capacity were sampled). Performance criteria stipulated within authorizations were also typically assessed (e.g. was there 80% survival of the riparian vegetation after the 1st growing year?). These assessments were primarily qualitative; visual observations were used to assess HADDs in many instances.

- 7% impacted "critical habitat," 64% impacted "important habitat," and 29% impacted "marginal habitat."

- Pre-impact assessments were conducted for 73% of the authorizations, and post-construction monitoring (based on area assessments) was required by 90% of the authorizations.

- From these files NNL was achieved in 10% of cases, in 4% NNL was not achieved, and for the remaining 86% the results are not known.

- The primary reason for our inability to determine whether NNL was achieved based on a review of the authorization files was due to poor record keeping, a low proponent compliance rate with monitoring requirements, the qualitative nature of the monitoring, and the failure of DFO/proponent to establish a proper baseline in pre-impact monitoring prior to the development.

- Only a small percentage of the total number of compensation projects in Canada has been evaluated, and of the studies that have been completed, most have employed qualitative methodologies, been narrowly scoped, and been regionally focused.

- The lack of independent, quantitative studies constrains DFO's ability to adaptively manage its habitat conservation program.

- These studies provide valuable information relating habitat compensation projects and their success in achieving NNL.

- We need to conduct more studies to improve our knowledge of compensation science, but this should be done at a "program" level. Also, future studies should aim to employ scientifically-based, quantitative methodologies.

- Field audits of compensation projects across Canada were evaluated from 52 authorizations between 1994 and 1997.

- Compensation was based on specifications in the authorizations and not on final fish production and the actual compensation ratio was less than that specified. The mean age of the projects was 4.4 years (range 2-9), and in total, 1.04 million m^2 of compensation habitat was audited.

- Compliance was low (58%-74%): 81% of authorizations were non compliant with riparian vegetation requirements. Eighty-six percent of authorizations had larger HADDs and/or smaller compensation than authorized. These were not small differences, and on average, HADDs were 389% larger than authorized.

- Assessment of 16 authorizations was made between 1994 and 1997 in relation to area compensated for and the compensation ratio, the magnitude of change in productivity (such as periphyton biomass, invertebrate density, diversity, fish density, and riparian cover). All 16 projects were located in riverine habitats, and 12 were like-for-like; 2 were like-for-unlike, and 2 were increasing the productivity of the existing habitat. Common compensation techniques included riparian re-vegetation, channel creation, habitat complexation (e.g. boulders, large woody debris, or pools). The mean age of projects was 4.3 years (range 2–9). Seventy-five percent of compensation projects had either larger HADD areas and/or smaller compensation than authorized in the in-channel category. Regarding riparian habitat, 88% of compensation projects had either larger HADD areas and/or smaller compensation than authorized. Also, mean actual compensation ratios were much smaller than required ratios.

- Assessment of authorizations revealed that in 12% of situations examined there was a net gain in the productivity of the habitat when the average compensation ratio ranged between 4 and 8:1, no net loss in 25% of cases (1:1 ratio), and a net loss in the remaining 63% of cases (0.74:1 ratio).

- Invertebrate indices were less variable than fish biomass in these assessments (it is possible to have no change in production (biomass) in a particular indicator but have a shift in species composition!). There is a need to select an array of biological indices in order to assess the productive capacity of fish habitat.

- The fact that considerable differences in diversity of species were not detected may be due to the tendency for most of the proponents to have implemented in-kind compensation (rather than like-for-unlike). This practice has been lauded due to its propensity to maintain biodiversity.

- Invertebrates and periphyton are rarely assessed in evaluations of compensatory projects.

- A multi-metric approach provides a more complete picture of habitat productivity, rather than simply using fish biomass as an indicator of habitat productivity.

- Invariably, habitat alterations do not exclusively affect a particular species in isolation of other biota.

- In many cases, selecting one surrogate of habitat productivity, rather than an array of ecological indicators at different trophic levels, would have led to erroneous conclusions.

- Projects that successfully achieved a net gain in habitat productivity were characterized by actual ratios of approximately 5:1.

- Canada's performance in achieving NNL is sobering considering that the assessment and evaluation only focused on site-specific impacts and ignored hydrological effects and disruption to landscape processes.

- In general, the monitoring requirements for habitat compensation in Canada are inadequate to determine long-term (>50 years) and cumulative ecosystem effects.

- Temporal losses of habitat productivity are inevitable when compensation habitats are developed after the HADD occurs. Furthermore, temporal losses are exacerbated due to the time lag until compensatory habitats become functional.

- Time between HADD occurrence, compensation development and compensation functionality was not a leading consideration by DFO in the authorizations that were audited. In general, compensation sites were selected opportunistically rather than based on ecological bottlenecks and potential for success. High ecosystem variability meant differences had to be large in order to detect responses, and, accordingly, in this respect our results can be considered conservative. Although more replicates would have assisted in determining differences in habitat productivity, the gross disparity in physical area of compensated versus impacted habitats was an over-riding factor for many projects. Unquestionably it is exceedingly difficult to achieve equivalent habitat productivity when replacing only a fraction of the habitat lost.

- The ability to replicate ecosystem function is limited and both improvements in compensation science and institutional approaches are necessary.

- Limited success in achieving NNL does not erode or invalidate the value of this goal of the Habitat Policy. Rather, it provides the impetus for change. However, it is important to acknowledge that compensation does not mean never having to say no to development proposals. Some habitats are not possible to compensate for.

- Failure to acknowledge the limitations of compensatory science raises the disturbing proposition that Canada's efforts to conserve fish habitat will not be achieving the goal of NNL.

- It was deduced that habitat compensation ratios should be in the order of 5:1 to achieve a net gain. To achieve no net loss of the productivity of aquatic habitat, compensation ratios should be 2 or 3:1. Temporal losses are, however, inevitable and the functional linkages within and among habitats need to be addressed.

- Science-based and simple methods are required are required to quantify net change in habitat productivity, and assessments should incorporate appropriate time scales.

- In terms of habitat area, it would appear on paper that Canada should be achieving a net gain of habitat productivity. However, upon inspection, the actual areas of compensation habitats are much less than required and actual HADD areas are much larger.

- Non compliance with HADD and compensation areas contributed to substantial losses of habitat. Across Canada, we consistently found that riparian habitat compensation was not sufficient to offset habitat losses. Habitat loss as a result of improperly-installed or designed compensatory structures (e.g. perched culverts, impassable weirs, dry channels) was also considerable. In many cases, these losses were thousands of square metres, exceeding the original HADD that necessitated the compensation habitat by orders of magnitude.

- Poorly designed compensatory works also caused habitat fragmentation by obstructing or impeding juvenile migration resulting in isolation of individuals from the rest of the population. Requirements in the authorizations were often vague and not measurable. In some cases, authorizations specified requirements that would be impossible to achieve. Poorly defined requirements gave rise to situations where proponents were entirely compliant (e.g. the channel was physically stable), yet functional success of the compensation habitat was doubtful (e.g. the channel was dry and disconnected from the watershed). Some compensation projects were exceptionally successful in achieving large net gains in habitat area. These projects were characterized by compensation ratios that exceeded 5:1.

- Although compensation ratios are intended to increase proceeding through the hierarchy of preferences (like-for-like, like-for-unlike, increase like productivity), this trend was not clear in the projects audited.

- There is a strong and growing reliance upon authorizations and associated fish habitat compensation as a mechanism to conserve fish habitat in Canada.

- Habitat compensation, as currently implemented in Canada, is at best slowing the rate of habitat loss. Increasing the amount of authorized compensatory habitat in the absence of institutional changes in implementation will not reverse this trend.

- Improvements in monitoring, enforcement and compensation ratios are necessary, to improve our ability to achieve and to measure NNL, to improve corporate memory, learning, and transparency in decision making, and use larger compensation ratios (compensatory habitat area should be at least equal to the area being lost, and a minimum compensation ratio of 2:1 should be required in most instances).

- Compensatory habitat should be constructed prior to or concurrent with HADD occurrence to ensure the functionality of compensatory habitat, proponent compliance, and to reduce temporal loss of productive capacity.

- A simple, science-based approach to assessing the effectiveness of compensatory habitat in achieving NNL should be undertaken for most compensation projects. The objectives of this approach should be to quantify the net change in habitat productivity. That is, to quantify the net change in habitat productive capacity, monitoring programs should employ a multi-metric approach (fish density and biomass per unit area, macroinvertebrate density and diversity, periphyton density and diversity), an appropriate experimental design, surrogate variables for productive capacity measured at HADD and control sites before and after project implementation.

- Monitoring programs should have a minimum of 1 year of pre-impact monitoring (preferably 2 years), and the monitoring duration should be lengthened (e.g. 10 years) and could be "pulsed" (e.g. years 1, 5, and 10).

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Northern Ecosystem Initiative

Environment Canada

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General comments

- The intent of the Northern Ecosystem Initiative is not only to be a funding source. It is our hope that we will provide seed money from which more funds will be raised. We have $175 K annually for the next 4 years, so we are seeking partnerships. At the end of the Northern Ecosystem Initiative project, we expect that projects will have become self sustaining. If we have projects across the north – in Nunavut, Quebec, and the Northwest Territories, information should be transferable and people would have templates so their work could be standardized.

- The Resource Use Table (Paula Pacholek, chair) is currently focusing Phase 2 activities of the Northern Ecosystem Initiative on determining thresholds for cumulative effects on the environment due to development.

- The Resource Use Table was a very broad-based group in Phase 1 of the Northern Ecosystem Initiative and over 5 years a number of projects were funded, but with mixed results. Phase 2 has been developed from the lessons learned during Phase 1 of the initiative.

- The Northern Ecosystem Initiative is also represented in the Great Lakes and on the West Coast with (Georgia Basin Ecosystem Initiative). Great Lakes issues are primarily focused on contaminated sites. Environment Canada (EC) has coordinated community consultations and the production of fact sheets.

- Very broad environmental issues exist north of 60, encompassing topics such as contaminated sites, climate change, and monitoring of impacts of resource use.

- The Phase 2 call for proposals occurred in July and August 2003.

- Studies are focused on biological mapping, and tools for advancing cumulative effects assessment (models, etc.).

- The question is how do we pull the information together to start managing better for cumulative effects? The Northern Ecosystem Initiative has funded a number of projects in an *ad hoc* fashion, but it has not necessarily led to significant findings.

Some projects deal with caribou and others traditional knowledge – they are quite diverse.

- A meeting was held in Calgary, December 2003; we invited proponents of both funded and not funded projects – social scientists, biological cumulative effects specialists, government people, and contractors (DFO was not invited). Impetus for this workshop stemmed from the Diavik mine comprehensive study and commitments made by Indian and Northern Affairs Canada (INAC) and EC to be involved in this type of work. George Hegmann of Access Consulting, Calgary, has been very much involved in the north: in the Yukon and in the Inuvialuit Settlement Region. Hegmann wrote the practitioners' guide to cumulative effects assessment in Inuvialuit.

- At the workshop, information management was a topic of much interest, and databases and systems were reviewed in order to address needs. Aboriginal communities voiced a desire to better manage their own information. A component in our overall framework is data management. However, because EC's Canadian Information System for the Environment is established south of 60, we will join with that initiative. Accordingly, we have put aside information management system development to focus on the thresholds work – it is the key issue for us at present. Cumulative effects researchers have said that one should not carry out project-by-project assessments, and that an understanding of thresholds is required to add to decision-making processes for different species.

- Three groups have been organized which are for aquatic, terrestrial, and social science concerns.

- We are trying to get the social science group to consider setting limits – the decision makers are the community. Social science is evolving at a rate where there can be coordination with communities.

- Social science needs to develop the indicators or thresholds, that is, the point of no return, using dose-response curves. We could then take these thresholds to the communities and determine what is acceptable to them. Probably the communities would make the decision that there is too much activity on the land. We are struggling with what are the appropriate indicators within the communities. *For example, if there are no moose nearby is that an indicator of impacts on the moose population or natural moose population changes?*

- In our view, the social science aspect is key to building community relations in the north. However, to date, we have not approached the diamond mining companies and worked with them. This is because of financial constraints, and because of the new approach being developed on thresholds. We want the researchers to convince us about the importance of thresholds so that we may take these arguments to the communities; we want to have a solid proposal before engaging too many people.

- In the north, livelihoods are based on, for example, fish and caribou, so we cannot wait until populations of these animals decline and "crash." What drives populations? Is it the human interaction, or natural population variation? We are looking at caribou movement and trying to determine if diversions from historic migration routes are relevant to reproducing successfully (Don Russell). The challenge is to make the findings relevant to people, that is, the impacts on the environment from industries and other activities.

- Criteria are being developed for the determination of environmental thresholds for cumulative effects. With the work of Monique Dubé at the National Water Research Institute in Saskatoon (aquatic cumulative effects), thresholds are being seen as an increasingly important management tool for use in assessments of developments.

- The development threshold setting has the highest priority for us.

- A number of papers have been published on Yukon air and water quality indices, and for caribou management. For example, snowmobile activity and impacts on caribou has become important for decision makers. The director of the group is interested in relating human activity to dose-response criteria. Multi-metric indicators have been developed by Fritz Mueller. Also involved are George Hegmann, Stan Booten, Sheila Montgomery, Ralph Porkowitz, Don Russell, and others. However, we have no examples of responses to thresholds. We need to complete some dose-response work before we can advise others. Our role is to communicate that the science exists, and that good decisions should be based on it.

- Researchers such as Fritz Mueller, Erin Bain and Stan Booten indicated that they would rather receive 4 years of funding at the outset, because in 4 years much may change. But because we have only $175 K each year it will not be happening. We want to ensure that the results we obtain are relevant to the north. To date, research has been centred in the south. In Alberta, the caribou populations "crashed," so we question whether we want to apply models used to manage the Alberta animals to the more northern herds? The models are only as good as the information put into them. We have some baseline work from the Northwest Territories, and with the data from Alberta, better management models should result.

Consultations regarding scientific considerations

General

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Collaborative Research and Development (CRD) grants
http://www.nserc.ca/professors_e.asp?nav=profnav&lbi=b3

- Applicants could lever NSERC money if there are funding partnerships with industry. CRD grants average $60 K per project. With a large, healthy company, NSERC's flexible funding formula could be 50-50: Industry-NSERC, and half of Industry's contribution could be in kind for environmental work. There is about a 3-month turnaround time on NSERC project approvals, and projects are 3-5 years in duration, on average. The initial request to NSERC usually would come from a university, with the "buy in" of industry. Then NSERC would establish a direct link with the industry, potentially in collaboration with a Department such as DFO. The following criteria for projects are described in detail on the NSERC CRD website: *Scientific merit; Research competence; Industrial relevance; Private-sector support; Contribution to the training of highly qualified personnel; Benefit to Canada; University commitment and infrastructure.*

- **Northern Research Chairs**
  http://www.nserc.ca/news/2002/p020403b.htm
  NSERC has connections with a 9,000-person community of researchers through the Northern Research Chairs program and provides $200 K per year for each Chair for salary and research over 5 years. DFO should convince industry to fund Chairs for long-term research.

- **Strategic Project grants**
  http://www.nserc.ca/professors_e.asp?nav=profnavandlbi=b1
  NSERC holds an annual competition for research project grants under 4 very broad categories: *Biosciences; Environment and Sustainable Development; Information and Communications Technologies; Value-Added Products and Processes.* Strategic Project grants average $30 K per year.

- **Other**
  NSERC has Research Partner Agreements with some line Departments and industry (1/3 share each).

- Use of Adjunct Professorships within DFO to access NSERC grants is better focused at training of graduate students. It would be preferable for grants to be under the tutelage of full professors.

Habitat and related science:

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Comments regarding the 4 questions posed to industry:
1. What are the priority research/information needs regarding diamond mining and aquatic systems?

2. What are your opinions regarding collaboration with DFO/universities/other industries?
3. Regarding compensation/restoration actions, who decided upon that which was appropriate, who assesses the success/failure of them and what are the measures of success?
4. What are the limitations to the growth of the industry, and what is the forecast for the future?

Response:

- These comments are given in a context that pre-supposes major expansion of the industry and activities over large areas. By "large areas" I mean to imply something that may ultimately be comparable to the placer mining situation.

- The diamond mining industry has staked an area about half of the size of Alberta. I am unable to infer how extensive the activities will be.

- If diamond mining is highly likely to remain confined to a small number of restricted areas, the comments about understanding ecosystem level processes may not be very relevant. However, the first placer operation in Yukon began with impacts on one stream. The first logging in BC began with low-level impacts in isolated local areas along inlets. The comments about research needs are predicated on potential developments that are extensive and/or numerous in the Canadian north.

- The following comments will address needs at two levels. While it is clear that there may be priorities for research, it should be equally clear that if major industrial activity is about to bloom, there will be a need for a suite of inter-connected research activities. I will therefore consider two inter-dependent levels of research activity.

Ecosystem or "process" level research

Why this level?

- Many industrial activities have multiple and cumulative impacts. They may occur over time and the nature of impacts may change with time. Within a particular class of industrial activity, the significance of different parts of the activity may differ. *E.g. sediment impacts were of first order significance in a logging operation in the Clearwater River system. In Carnation Creek, the most important impacts of forestry activities involved channel changes (changes in large woody debris dynamics), and temperature changes. In the Carnation Creek study it was necessary to understand how processes operated over time in order to know how fish were being affected by the forestry program. In Carnation Creek, initial effects involved temperature changes and streamside-related channel structure alterations. In the longer term, impacts involved channel changes caused by up-slope activities.*

Features of ecosystem studies

If there is a desire to understand:

- The nature of cumulative impacts;
- The types of impacts that occur over time;
- How different age classes of fish are affected; and
- What impacts may be affecting invertebrates and production,

it is necessary to carry out long-term studies with spatial and temporal controls.

Without listing in detail, it is necessary to monitor, before and during the operation:

- Meteorological conditions;
- Hydrology;
- Water quality (temperature, sediment, oxygen, nutrient characteristics);
- Channel conditions;
- Primary production and invertebrate composition; and
- Fish species, age composition, and growth.

- These elements may make it appear a program is one of simple monitoring. There is great scientific challenge in keeping such programs going long enough to generate understanding of how processes operate, and carrying out in-depth analysis of the data coming from them. There were many things in the Carnation Creek work that we would not have understood without the sophisticated analyses that L.B. Holtby and J.C. Scrivener were able to provide.

- Complex, long-term process studies may not be possible for financial or other reasons. If this is the case, studies that examine separate elements within a system undergoing impacts may be the only option.

Single species or "separate element" studies

- I will focus my comments on fish in particular in this section. I have discussed parts of this with Dr. J. D. McPhail who is very knowledgeable about Arctic and sub-Arctic fishes.

- The systematics of fishes in the western Arctic are fairly well understood as is their broad distribution. J. D. McPhail (personal communication) believes that knowledge of lake trout, lake whitefish and ninespine stickleback is well developed. Systematic relationships within the ciscos, and distribution of the Arctic charr are still problematic.

- Detailed life history information, at a local level, may not be well developed for many species (J.D. McPhail; personal communication). Post-glacial fish distribution in the Arctic, east of the Mackenzie River occurred from the Bering refuge (about 27 species wholly or in part), or from the Mississippi refuge (about 30 species wholly or in part), (McPhail and Lindsey 1970). East of Great Slave Lake, southward, various populations may have different origins. The implications of such different origins to life history detail are not known.

- The specific elements of the biology of fishes that may be important are:
    - Details of habitat use by season and, where appropriate, diel period – for each species and each life stage within the species. By habitat use I refer to both macro- and microhabitat;
    - Location of reproduction environments, routes to and from them;
    - Reproductive behavior and habitat;
    - Incubation rates;
    - Food habits at various stages;
    - Biology of food organisms;
    - Winter behavior of fish;
    - Physiological features of species – temperature tolerance, oxygen requirements, sediment and turbidity tolerance and, responses to contaminants that may arise from within diamond mining operations (I don't know if or what these might be); and
    - Actual and/or potential limiting factors for populations.

I will not enter into detail on compensation and restoration. The chapter draft on restoration from the book, Fishes and forestry (Northcote and Hartman 2004), provides some discussion about how I think restoration planning should be carried out. Hartman and Miles (2001) provide a lot more discussion of various technical approaches for some kinds of compensation.

In the paper that I received from you there were three parts to the title of this topic:

- Who decided upon that which was appropriate?
- Who assesses the success or failure of them?
- What are the measures of success?

The comments that follow will apply to situations where restoration programs are being carried out because of concern about specific impacts on one or more species of fish.

"Who decided upon that which was appropriate?"

- I presume that "decided" should read "decides" above. There are two aspects to the first question. It seems to me that one aspect is a policy matter, but it is one that troubles me.

- *The process in which government agrees to a development, recognizes that habitat will be lost, requires compensation work, and then gets involved in designing such works is filled with risk. In this scenario, a developer can propose something without full and sound information or understanding, government (without full competence to* *understand the situation either) gets involved and agrees to a plan. When or if the plan fails, the developer is essentially off the hook because the regulating agency was involved: "due diligence."*

- *My own view is that if government wishes to see a development proceed, but with compensation, it should agree to the project, set targets for damage control and compensation, and require that the developer gets full and proper advice to accomplish the project with end results prescribed. If the developer fails to do this and fails to get sound technical advice, the responsibility and consequences are with them.*

  I put all of the above in italics because it was not what you asked me about. However, since I am an unpaid and un-contracted commentator, I will give you my two cents worth.

- The question of who decides what is appropriate may be a matter of operational policy. The critical issue is how it is decided what is appropriate.

  In many of the projects that I, or Mike Miles and I, have examined, the measures required were usually determined on the basis of judgment, not science.

  Projects were initiated to improve fish numbers without a sound determination of what was limiting them. In cases where major projects are launched and large amounts of money are to be spent, it is imperative that people know specifically "what needs to be fixed." See my comments on limiting factors in Hartman (2004).

"Who assesses success or failure?"

- It may not be critical who assesses success or failure. However, it is critical how success or failure is established, and over what time line the evaluation is made. The targets and the time lines for evaluation should be set, and the process funded for as long as needed.

- Time lines should be established on an ecological basis rather than on some administrative criterion.

- Regular reports should document success based on whatever criteria were selected.

- The methodology of evaluation is critical. In some projects that I have seen, evaluators have counted fish around structures rather than assessing whether or not there was an increase in fish production over the total area. Changes in distribution and changes in production are not the same thing. In many programs, where physical structures (weirs, debris structures, log jams, pools, etc.) are built, existence of the structure is used as a criterion for biological function and success. These two things are not the same.

- It may appear to be obvious, but in measuring success, the evaluation must assess the difference between what was obtained after a restoration project and what would have been there without it. I have seen situations in which restoration projects attempt to take credit for all fish in the stream.

- Whatever a project is intended to do should be set out in a clear statement of objectives. The success or failure of a program should be measured against the objectives that were set out when it was planned. This appears to be obvious, but it does not always occur.

- Failure should be reported just as clearly as success.

"What are the measures of success?"

- The measures of success should be based upon the problem being solved.

- I have trouble answering this one because compensation or restoration work may have different objectives. It seems to me that compensation work may actually create new habitat to replace that lost elsewhere. Restoration work may be intended to rehabilitate existing habitat that has been damaged. I understand that success of some compensation work may be measured by the area of new eelgrass or mud-flat habitat created. It may not involve actual measurement of the amount fish production increase arising from the project. It might be hard to evaluate the population improvement from such work.

- In restoration work (fish-oriented) success should be measured by the increment of population increase over what would have been there anyway. I can appreciate that people working with fish might look at population production (numerical) increase or increase in growth rate. If works are carried out in an area where there are several desirable species, evaluation must consider all species and life stages. In Alberta, some of the habitat improvement work increased the numbers of one year old fish, and got rid of the young of the year.

- I think that if compensation or restoration projects are carried out, it is essential to assess enough elements in the system to pick up such differences as growth changes, fecundity changes, population number changes (in various life stages), and indications of interaction effects among species.

I have written, albeit weakly, about the different questions listed. The other things that I think are important include:

- Evaluating long enough so that effects are given a chance to show up;
- Having people around who know how to evaluate and report objectively;
- Having funding for evaluation and maintenance so that a useful project does not fail simply because part of the works were lost in a storm or some such thing;

- Having teams of different specialists in the design, build and evaluate stages. If works are to be put into streams or rivers, it is crucial to have specialists around who understand such systems. If re-vegetation work is to be done it is important to have the appropriate plant specialists around; and
- Knowing enough about the ecosystem to be able to choose the appropriate evaluation criteria.

The following three additional points were provided by Gordon Hartman on November 30, 2004 following his review of a Draft Summary Report (DSR) that the authors developed for this project.

1) The DSR indicates the large total scale of the three mining activities. It indicates very clearly the requirement for research. Such requirement is stressed repeatedly in the Appendix with Consultation Comments. I will not repeat my appendix comments regarding the need for ecosystem-level process research. However, such need is even more clear to me after reading the DSR and the appendix comments.

2) The needs for research funding and staffing must be put up alongside of the revenues and/or income from the industry:

> a) DSR page 13: Annual revenue from 3 diamond mines: $10 billion over 3 years: $500 million/year.
> b) DSR page 15: Expected new revenues from oil sands to government from 1997 to 2025 increased to: $200 billion, about $7.14 billion/year.
> c) DSR page 16: Present gold production value from placer mining about $40 million/year.

These figures place the revenue from northern mining at about $7.7 billion/year. The amounts spent specifically on staffing and research, for northern work by DFO, represent a remarkably small fraction of the revenue stream. At one quarter of one percent, research funding would be about $19 million. Research funding is not near to $19 million. Strong, long-term, ecosystem-based process research should be funded to be carried out in this fragile, vulnerable and changing part of Canada, subjected as it is to expanding and cumulative impacts. This type of work must be led by government as was done very successfully for years in the Carnation Creek watershed project (Hartman and Scrivener 1990). The research should be carried out soon, so that, as much as possible, information can be applied to ongoing planning and management, rather than appearing as historical documentation of ecosystem damage and loss. There is no excuse for anything less.

3) These comments may appear to be rhetorical. However, they represent a deep and serious concern that I have. (Keep in mind that I have worked in government research, administration and management, for 27 years, and been involved in consulting for ten more years). The DSR, while not stating so specifically, makes it clear that mining will proceed. Fish protection will be fitted in if possible, and as cheaply as possible. The inadequate funding of DFO research and staffing are testimony to this.

As a citizen and semi-retired scientist, I would prefer that legends in illustrations such as Figure 16, give the departmental goals as I believe they are becoming perceived by society: "Playing a role in industrial development and job creation, and accommodating the protection of fisheries values to the extent that they don't cost too much or prevent development."

I appreciate that some of my comments may appear to be hard. However, I do not believe that DFO is currently meeting its obligations in research and management in spite of the efforts of the good people that are out on the ground doing their best. There are needs for more than catchy "administrative pathway systems" in northern management. They are: sound science, development of field experience, staff continuity and overall commitment to the resource.

As a postscript to these comments, I point out that DFO has abandoned essentially all fish-forestry research in BC. A host of new developments are taking place in the province, and we are not being prepared for them.

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Arctic/northern fish ecology/hydrology

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Research priorities in the Canadian Arctic

- My work has primarily been in the marine environment – developing and implementing Arctic science programs for DFO. As a result, terrestrial and freshwater areas have not been my main direction.

  In 2001 there was an increase in oil and gas activity in the north and a science program, that we currently oversee with headquarters, was developed to address this development.

  My goal has been to build a program that is defensible and sensible, and that has linkages interdepartmentally, and within the department.

- Research to increase scientific knowledge relating to oil and gas exploration and development includes construction aspects that can directly impact on fish habitat.

- Scientists are working with the oil and gas industry and in consultation with communities and other government departments (e.g. INAC) on proposals to address information needs in the Arctic. While we did not get all of the funding requested we obtained monies to permit us to move forward on key issues.

- The question is do we have enough baseline information on fisheries in northern Canada?

- Do the studies of past 30 years give us enough to be able to respond? More fundamental information seems to be needed, for example, on permafrost, on sediment, on construction camps, on impacts on the Mackenzie River, and whether fish can spawn and survive there.

- We are working with scientists and habitat managers to obtain the appropriate expertise, for example, on sediments. We need to hire scientists who can develop the required expertise.

- Sediment effects at the fish population and individual level need to be considered. In this context, we have a large (8,000-page) report being completed this fall and need a scientific review of its content. This expertise is not available within DFO given how busy everyone is. We need to say to Central Agencies if you give Science funding, this is what it will be used for.

- Lake drawdown is a major issue – we need the basic criteria to use. DFO has not developed the science which is required to evaluate lakes so that industry can make better decisions and not impact the fishery.

- We do not have a good understanding of seismic and its impacts.

- A large experiment is underway through the Program of Energy Research and Development (PERD) funding [a science and technology program which designs and funds work done interdepartmentally by 12 federal departments and agencies in support of NRCan's energy priorities. PERD has an annual budget of $57.6 million.

- A series of seismic issues are being studied at various levels – biological, physiological, and behavioral. This summer (2004) there will be caged-fish experiments to investigate impacts on various sizes of fish. A great deal of work is required in order to make defensible recommendations.

- Central Agencies seem to believe that the Government of Canada does not need to do research in the Arctic concerning oil and gas. As they see it, under CEAA, DFO could identify the science that is required and have industry carry out the research. Would industry fund basic northern research? Industry would not investigate cumulative effects or climate change.

- Central Agencies do not feel that government needs this sort of expertise, when it can buy it. It was a huge disappointment when the inland habitat issues were taken back by DFO, but the MC did not address the associated science requirements. This presented a severe shortcoming in C&A Region, and broader difficulties across the Department. With respect to oil and gas, we are making sure that this does not happen again. Although we received only 35% of the requested funding for northern oil and gas, there are the funds to address some key scientific issues.

- There is also the issue of utilizing different materials for construction along the pipeline route, for example, the types of sand and gravel.

- We want to investigate creation of borrow pits along areas of the Mackenzie River that could result in the development of fish habitat. This may provide a solution to the broader industrial "footprint" issue, although we need to do the research to substantiate our decisions.

- To be effective in supporting the requirement that the Arctic will be in the mainstream of Canada's economy, we will have to carry out scientific research and be prepared to work outside our typical "comfort zone."

- Within DFO Habitat Management's regulatory role, there is the ability to impose requirements on industry to contribute to developing solutions to mitigate and avoid impacts. Creating a research fund to address such issues would be a very good approach. This would be in line with the spirit of co-operation, given that industry wants to be there for the long term, and DFO could be included as a fully-contributing partner, without a conflict of interest.

- With respect to concerns over oil, the Environmental Science Research Fund (ESRF) is in place. The oil industry is taxed depending on the amount of exploration that is carried out, and this taxation creates a stable fund for research (led by INAC).

Models exist for cooperative research through ESRF and PERD, and they provide financial leverage to achieve a common goal.

- Impacts on fish and fish habitat associated with construction and pipelines will include the effects of increased access to remote areas, and associated exploitation of fish. Increased fishing pressure may change the dynamics of fisheries management even though we presently do not have the fundamental knowledge base about fish and fisheries in these areas.

- Perhaps there are there better ways of understanding impacts in the Canadian north than, for example, traditional approaches such as searching for areas where fish spawn. For example, it would be important to consider prey species (invertebrates, fish) in areas that freeze to the bottom. Where they can burrow and survive over winter they will provide food for the success of future fisheries on the predatory fishes that feed on them.

- Energy (food) requirements are significant considerations in the typically cold and ultra-oligotrophic Arctic tundra environment.

- DFO cannot impose on industry the responsibility to do basic research on the issues mentioned here; the research must be a cooperative undertaking.

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General discussion and current Arctic research

Points:

- Food webs, stable isotopes, food, parasites, disease, trophic patterns, in large rivers (and cultured fish). Hope to model small Arctic lake communities based on trophic structure.

- Modeling 3-D river systems regarding fish habitat, sonar/acoustic technology employed and GIS mapping.

- Status and behavior of sturgeon in lakes, (SARA money for sturgeon and telemetry studies). Cultured and wild sturgeon comparison regarding use of habitat.

- Chitty Lake, north of Yellowknife is a small deep lake that is isolated in winter. Mike Healey studied this lake and there is a 30-year data set; should permit definition of the use of habitat. Some telemetry studies planned for Chitty Lake – location tags, and possibly depth tags. Vemco telemetry systems are costly yet they provide large data sets e.g. on swimming speed. Tags could be placed on lake trout and movements tracked over winter.

- Bio-energetics – lateral flow of species – cannibalistic burbot/pond smelt – keystone species?

- Trophic feeding levels, but not biochemistry, are being studied. Need to know what has been eaten by different age classes of fish e.g. burbot eat burbot (and also mercury concentration increases with age). Some lake outlets may freeze to the bottom and thereby the lakes become isolated over winter. Predation can occur in such prey-concentrated areas.

- Community component – incorporate traditional ecological knowledge (TEK) (elders like fish with colored flesh) – have to rationalize to a wider public what we are doing; has to be incorporated into decision making.

- People question DFO's Index of Biotic Integrity for the Arctic, but how little specific information we have.

- Regarding cooperative research with industry, if it is good science then industry will work with DFO, but it is important to convince industry the work has value to them and to focus "the problem" from the outset. It also has to be intellectually interesting.

- Valid empirical information is needed to test models, for strong mitigation measures require good data sets. For example, an audit is required on the validity of the 2:1 compensation ratio for achieving no net loss of fish habitat. Currently we are some way from having good models (in this regard, Habitat Suitability Indices can be inaccurate).

- There is a need for Centres of Excellence for Arctic studies, to be linked with industry.

Terry Dick (June 14, 2004).

- A lot has happened since our talk. I attach a brief report on data collection on the Mackenzie River last summer and future work at that time.

- We are finalizing our interpretations of the data and will choose a site shortly for further detailed studies this summer (small watersheds and small secondary streams entering the Mackenzie River) a graduate student starts in June).

- I am also a co-applicant on a Social Science and Humanities Research Council (SSHRC) proposal (we have received LOI funding) to set up a community environmental centre at Deline on Great Bear Lake with the long-term objective of an educational program emphasizing the ecosystem approach for the entire watershed.

- *The Chitty Lake study and a small Arctic lake study near Iqaluit will continue through summer 2004. We have mapped and described substrate in Chitty Lake and will start a 3-year fish movement study this summer of lake trout, whitefish and pike and continue trophic feeding studies as it relates to substrate, depth and temperature, seasonally/yearly (some of our tags will last for 3 years.) This study has 2 graduate students working on different aspects.*

- The Arctic lake study will run for 1 year and deals with Arctic charr, again related to habitat, feeding, etc. (graduate student starts this July). This work will be expanded to Resolute and Char Lakes in 2005.

- Our research in Iqaluit incorporates working (teaching/training/hiring students) with Nunavut Arctic College and the Nunavut Research Institute and the development and transfer of knowledge to the community and the Hunter and Trappers Association (2 additional graduate students work here, one has received an NSERC northern internship).

- I have also contacted the government of the Northwest Territories to explore the possibility of study at Daring Lake (you are probably aware that it is in the heart of diamond country) as there is beginning to be a fairly comprehensive data set for the terrestrial system and some of the water parameters. I will take a look at this system summer 2004 to determine if I will start a project.

- In general your synthesis of my comments is accurate but as you see from my above comment I am moving forward quickly. My view on Centres of Excellence has changed somewhat from when I spoke to you.

- I believe now that a Network of Centres of Excellence is really needed that deal with people and natural resources (food and employment) and the environment (this includes traditional values and mitigation issues); the umbrella for all this is building capacity in the north for decision making.

Brief outline of Research Program in Mackenzie River

Mackenzie River Fish Habitat and Water Quality Project

***Rationale**: The Mackenzie River is Canada's largest northern river and represents a 1,800-km north-south gradient of different fish habitats and water inputs i.e. montane and tundra. There is a need to understand natural changes that occur along its length and once these are known the river can serve as a monitor of warming trends and other perturbations. Changes in active layer thickness will affect slope stability (already noticeable along the river and its tributaries) and hydrology and this may be expressed through changes in soil moisture, stream flows and nutrient availability which will likely impact the aquatic ecology of an area. Data were collected from the Mackenzie River basin about 30 years ago but little new information on fish or their habitat has been collected since that time. A "gaps in knowledge" report in 1981* *indicates that little is known about the tributaries of the Mackenzie River concerning fish communities. In the past 30 years some major changes in the region have occurred; there has been a warming trend, some loss of permafrost and reduced flows from some of the streams. In addition there have been major forest fires along some reaches of the Mackenzie River. While previous studies provide some baseline information new technologies bring additional resolution to variables which measure aquatic resources in the basin. For example, use of acoustic technologies and GIS allow us to map and document substrate distribution more accurately and new analytical tools allow us to assess water quality more precisely and completely. Consequently we are able to detect changes in the aquatic environment due to natural processes, such as changing patterns of precipitation and loss of permafrost and anthropogenic factors. While there are numerous large rivers with substantial flows there are many small streams with reduced flow in the late summer, yet these streams are shallow, have warmer waters and support substantial invertebrate communities. Although not well documented many of these streams support communities of small fish species, and some serve as spawning sites for migrating fish and rearing areas for juveniles. Furthermore, there are considerable subsistence fisheries along its length which may be impacted by change.*

During the summer of 2003 a whole-river study was initiated to measure fish habitat parameters, overall water quality and to collect water and substrate samples for mercury analyses. In addition, data were collected on stable isotopes in order to determine the proportional contribution of water sources along the river to obtain a cumulative footprint along the length of the river and a potential basis for use as fish markers in the future. Tree cores were collected along the Mackenzie River to explore possible terrestrial aquatic linkages using stable isotopes and trace elements.

***Initial collection of data**: Preliminary assessment of substrate using acoustic technology and confirmatory benthic grabs indicates that substrate complexity and type varies markedly along its length. By contrast, substrate homogeneity is highest in lower reaches of the river. Furthermore, it appears that much of the biotic productivity is in streams flowing into the Mackenzie River and in lakes associated with these streams. Horseshoe bend was identified in the gaps in knowledge report as a key fish spawning and habitat area. During the summer of 2003 the entire area has been mapped and bathymetry completed. Most of the smaller streams were shallow, could be waded at the stream mouth and were not navigable by small boats in August. Consequently, small increases in sedimentation or reductions in stream flows could reduce access in late summer and early fall to fish moving to upstream fall spawning sites.*

Using a combination of local knowledge and personal observations many of the community fishing sites along the Mackenzie River were identified. The following parameters and samples collected from sites along the Mackenzie River and some of its tributaries (brackets) were evaluated in 2003: in situ water parameters (88); stable isotopes (97); water trace elements and mercury (58); substrate and *bathymetry mapping (35); and tree cores (35). In addition, the physical features of many of the small streams were recorded.*

***Field season (2004)**: The next phase of the basin study is to evaluate biota at selected sites based on our assessment of the information collected during 2003. Community consultations are planned. We plan to collect data on fish, macroinvertebrates and zooplankton and expand the fish habitat program to the smaller tributary streams and lakes. The overall objective is to link the composition and structure of aquatic communities to natural processes occurring in the local environments, both aquatic and terrestrial.*

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Research needs regarding northern Canada and issues surrounding environmental changes due to diamond mining

- There has been little research carried out on species of fish and their habitat in northern Canada relative to that undertaken in more southern areas (e.g. Great Lakes).

- There is a need for basic limnological research programs to be undertaken in regions that are not disturbed by human activities.

- Such research should be carried out over a long period of time (years). Shorter-term surveys and sampling would be carried out during the course of these programs.

Lake morphometry and productivity

- Lake morphometry is an extremely important topic to consider, as this can be a predictive tool relating to biological productivity.

- The morphoedaphic index that relates volume and depth to total dissolved solids could be very useful in predicting fish yields from lakes in the Arctic.

- Productivity of lakes is related to thermal regimes; very shallow lakes may heat up during summer and be quite productive, whereas deeper and larger lakes may not heat up to the same extent and accordingly may be less productive in summer.

- Based upon determinations of lake morphometry one could predict species occurrence. Thermal regime and food of fish are controlled by lake morphometry. Even under ice cover there is algal production, but we need to know what lake conditions are at this time of the year.

- At the end of diamond mining the pits will become ultra-oligotrophic lakes and may not turnover.

Comments regarding lake trout in Arctic lakes

- Virtually nothing is known about the underyearlings (tributary streams are used by few young lake trout).

- There is information on spawning areas that are easy to determine, but because spawning may not be each year mistakes can be made regarding the use of these areas.

- Adults require critical conditions before spawning (a food-habitat issue).

- The survival of juveniles over winter could affect population structure when space is limiting.

Arctic ecosystems

- Arctic ecosystems are always subjected to extreme stress and they have become resilient over a number of years through meeting these conditions.

- Arctic charr and lake trout are antagonistic towards each other, but the charr will drive out lake trout. In some lakes there is one species of fish (with or without sticklebacks), but most have supported lake trout at some time.

- The productivity of Arctic lakes will always be low so one should decide what "we" are managing for (there will always be lake trout). However, where populations of fish are fished there could be a problem of sustaining the fish community of the lake.

- Great Bear Lake is very unproductive. There is no commercial fishing but subsistence fisheries exist and sport fishing occurs.

- Fertilization of the lake is the only way to improve food supplies.

Priority research

- There is a need for fundamental limnological studies in the Arctic to be carried out over significant periods of time. This work is very difficult to carry out, and it requires a commitment to long-term research.

- Such studies are needed on unperturbed (by humans) systems to provide baseline information.

- Over the shorter term, surveys of primary production, benthos and fish should occur.

- The productivity of the littoral zones of Arctic lakes (studies when the areas are ice free and also under ice) and their use as a refuge for juvenile fish should also be studied.

- Information contained in the book published by Lionel (Johnson 2002) includes an insight into Arctic ecology. Comments are provided on lake ecosystems and deductions are made regarding the forces that molded and influence their ecology. Accordingly, information within this publication would assist in setting the direction and content of limnological research in the Arctic.

- *"The most suitable starting point in the investigation of complex systems is the simplest system available which contains all the parameters of interest. The investigation should be planned in such a way as to allow the development of strong inferences which may then be tested in more complex systems"* (Platt 1964; cited by Johnson 2002).

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Issues re fish habitat management re diamond mining in Canada's north

1. Canada's responsibility as a northern country and research performance relative to other developed nations with similar regions.

- To my knowledge, Canadian scientists (including fish habitat ecologists) doing research in the northern part of the country are doing their work on shoestring budgets relative to other nations. This lack of program research is a limiting factor for DFO scientists and managers trying to implement policy in the north.

- As an example, the US has a site in Alaska (Bonanza Creek) which is part of the US National Science Foundation's Long-Term Ecological Research (LTER) program. The LTER work is done by both academics and agency scientists and has produced a wealth of knowledge over the years.

- The only vaguely comparable "network" that I am aware of in Canada is the Ecological Monitoring and Assessment Network (EMAN) run by Environment Canada but EMAN is primarily a citizen science program that does not seem to produce peer-reviewed science.

- The lack of support for long-term ecological research is of course systemic in Canada but for northern Canada with likely decade-scale ecological responses to environmental perturbations it is particularly important.

- I would strongly recommend that DFO try to set up a LTER-like tundra network involving other agencies such as EC, NRCan, and the universities. Perhaps the need for information on the impact of diamond mining will precipitate a network.

- Another factor may be the perceived non-charismatic nature of tundra fish relative to whales in the northern seas – DFO Science seems to focus on marine ecology in the north. In the past there was huge funding for research in the Beaufort because of potential oil exploration. The problem may be a lack of profile of the impact of diamond mining. There have been many stories in the newspapers about the diamonds but not many about how the mining is changing the landscape.

2. The problem of compensation for fish habitat loss

- This is a problem that has been plaguing DFO Science and managers since 1986. Part of the problem goes back (yet again) to the problem of measuring productivity capacity (PC).

- Habitat managers, of necessity, need relatively simple tools to measure loss of PC and compensation for same, and this is why areal measures (m^2) of surrogates such as marsh area, pond area, etc. are used. But as is well known, compensation will always involve a habitat switch because habitat cannot be created *de novo*.

- Some functions will always be traded off and implicitly species are traded off *e.g. in the Fraser estuary, many hectares of salmonid rearing marsh have been constructed by filling in deeper areas of channel that is white sturgeon rearing habitat. But what is unknown here is the function which possibly links the two i.e. if the detritus produced by the constructed marshes is fuelling invertebrates that support both salmon and sturgeon, then perhaps the loss of deeper areas can be justified.*

- The functions of various fish habitats is usually only understood generally, especially their interrelated roles since there is always the desire to find the silver bullet i.e. the single limiting factor that controls the growth and survival of a fish population. I suspect this lack of knowledge of functions is also true for the boreal fish populations you are dealing with.

- This conjures up the idea of "critical" fish habitat which has taken on a new emphasis since SARA has come to pass. Howard Powles (Science, NHQ) defined critical fish habitat as the centre of the bulls eye (where the Minister can prosecute under SARA) with the FA the next layer out (where "normal" FA procedures are used, see Randall et al. 2003).

- However I think what is missing in the modern ecological context is the appreciation of the linkages between habitats.

- The 1986 Habitat Policy should really be revisited and tuned up with a strong emphasis on fish habitat *planning*, which is actually written into the Policy but is not very often used.

- As well, habitat scientists and managers need to become much more aware of the growing literature on landscape ecology as it relates to fish populations and how habitats are inter-dependent. For example, in the coastal zone the existence of beaches is usually dependent on maintenance of natural sediment movement from adjacent areas, often an eroding bluff. I have tried to emphasize this point in a number of papers (e.g. Levings 1999).

- In my view if we actually planned compensation works with this concept in mind we would be advancing a more scientifically-defensible methodology.

3. A suggestion for a focused study:

- With respect to future research I think it would be most important to set up some long term experiments that provide detailed comparisons between natural and developed (I assume these would be lakes dug out of the tundra) to compare the ecological functions.

- This work should be done before this kind of compensation is accepted by DFO. While this might be seen as "stalling" by the proponents, it is the only responsible course of action I can think of at this time.

- In addition to classical food web and survival studies, stable isotope analysis of fish tissue could be used to help determine if the carbon pathways from phytoplankton production or from shoreline vegetation (detritus) are functioning in the same way.

- This technique might be able to provide some answers of ecological function in a time frame of 5-10 years which I believe might be the time required for equilibrium to be set up, but I am only surmising, it might take longer or shorter.

I hope these brief comments help and please let me know if I can provide any clarification.

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1. What are the priority research/information needs regarding diamond mining and aquatic systems?

- Research is required to understand the implications of increases in total dissolved solids (TDS) at various levels of biological organization. The fresh waters in Canada's tundra are extremely dilute, that is, low in TDS and nutrients. Fish that live in this region are adapted to those environmental conditions. Diavik and Ekati effluents will cause a 4- to 5-fold increase in TDS at the outlet of the very large, Lac de Gras. TDS in Snap Lake will increase from 20 to 1000 mg/L as a result of diamond mining discharges.

- More research is required on what controls populations of fish in Arctic lakes.

- In order to examine the effects of habitat change on fish, the species to study should be chosen wisely. For example, round whitefish may be a more useful species to study than for example lake trout because its life span is shorter, yet it too spawns in the fall.

- The habitat requirements of fish in Arctic lakes need to be determined.

- Assumptions of "habitat values" for these fish have primarily been derived from information generated in warmer locations and, therefore, are not necessarily appropriate to use. This is an especially important consideration when assessing impacts, compensation and restoration measures.

- Rather than relying on water quality guidelines when assessing the acceptability of changes in water quality characteristics, studies of effects should be done at operating northern mines (diamond mines cannot be operated without producing nitrogen).

- An archiving of samples should occur to permit analysis of collections in the future. For example, samples of zooplankton that were collected by Diavik 5 years ago will be eliminated, beginning in next year. While there was an initial analysis of baseline data, no thorough analysis of zooplankton has occurred since.

2. Regarding compensation/restoration actions, who decided upon that which was appropriate, who assesses the success/failure of them and what are the measures of success?

- BHP provided DFO with $1.5 M for compensation for lost lake habitats.

- We do not know much about producing stream habitat for grayling, and less about restoring lake habitat in the north (rarely are diamond mines developed that do not require lakes to be drained or filled with tailings). Originally the water level in Paul Lake was to be raised to offset the loss of small lakes. $1.5 M was the cost of a dam at the outlet of Paul Lake. However, concerns were raised about mobilizing mercury, so the proposal was abandoned.

- A series of experiments could be done to assess fertilization effects on dissolved oxygen in lakes over winter. Fertilization is a compensation option in a location such as Great Central Lake (southern BC) which does not freeze. However, the lakes in the north have a long period of ice cover, so precise information is required on how fertilization would affect dissolved oxygen over the 8- to 9-month winter period when there is a barrier to gas exchange from the lake to the atmosphere.

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Suggested research topic in relation to diamond mining

- *Research conducted by one of my previous graduate students (Simone de Rosemond) showed that during the first two years of operation of the mine (Aug. 1998 to Aug. 2000) surface water quality changed significantly in Cell E of the Long Lake Containment Facility (LLCF) as a result of effluent discharge to Cells B and C (seepage through the dykes). These changes included:*

- *a 4-fold increase in water hardness (5.5 to 20.9 mg/L)*
- *nearly a 2-fold increase in alkalinity (5.0 to 8.2 mg/L)*
- *a 4-fold increase in pH (6.6 to 7.2)*
- *a 3-6-fold increase in the concentration of several metals (e.g. Sr 8.1 to 35.0, Ba 6.6 to 24.3, Mo <1.0 to 6.3 ug/L)*

- Although these increases and levels may appear small, and the overall metal concentrations are still below toxic thresholds, these increases occurred over only a two-year period.

- I expect that the levels are much higher now and will continue to increase, especially when tailings/effluent is deposited directly into Cell D.

- I also expect that these increased loads have now resulted in water quality changes downstream of the discharge point from Cell E (e.g. outside of the LLCF).

- Over time, these increases could result in species shifts in the invertebrate, especially macrozooplankton, community and thus in the food base for juvenile fishes.

- *In support of this, Simone's evaluation of zooplankton populations in Cell E suggested that the early stages of change had already begun with soft-water, low pH adapted species such as Holopedium gibberum already beginning to show population decreases.*

- We predicted that as water hardness, alkalinity and pH continue to increase, these soft water, low pH adapted species will gradually be replaced with other species better able to tolerate the changing water quality.

- Whether there would be associated implications for fish populations that rely on zooplankton for a food source depends on the flexibility of those species to switch to other food organisms.

- If metal concentrations continue to increase at the initial rate, there could also be direct toxicity to sensitive species and life stages in years to come.

- The above is a long-winded way of saying that someone should be closely following the changes in water quality/chemistry downstream of the LLCF and assess the associated risk to the native aquatic community.

General comments regarding fish ecology

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- We have years of data on whitefish and Aishihik Lake. Significant changes with respect to water levels (regulated system) due to record high water years followed years of drought.

- Littoral areas very important for young of the year fish are therefore susceptible to changing levels. Lake trout are not so affected.

- Lake trout exhibit straying within a population to exploit new areas and adapt to circumstances in environment – an evolutionary requirement.

- Unlike a salmon which gains 5 lb/year and dies when it spawns, lake trout put on 0.5 lb/year and spawn at 10-12 years, and repeatedly for 20 years. They can maintain the population even if they only spawn 1 time in 10 years.

- Temperature the most important habitat variable re ecology and behavior (Casselman's work) – lake trout need 10-12 °C water. Juveniles occupy littoral areas of lakes but as temperatures increase and become unfavorable the fish move to deeper water areas and beneath the adults that occupy the prime habitat. Hence there is some risk of predation by doing this (one assumes staying in warm water will prevent fish from growing and storing energy reserves re winter survival). Juvenile lake trout moved to steep slopes close to shore when access to shallow preferred littoral areas was not available.

- Larger lake trout are piscivorous; smaller ones are insectivorous.

- Because of the importance of temperature, climate change is a significant issue.

- Regarding climate change the juveniles would be very vulnerable because of requirements to occupy nearshore areas.

- Females put on 20% body weight over 2.5 months from 21 June therefore they must feed voraciously (plankton diet less conducive to this, and in food-limited environment pre-spawning feeding by females may not be sustainable year after year). Adults are very vulnerable in nearshore areas in June when most fishing takes place. Females need to put on weight, males less so and 95% of lake trout captured in Atlin are females.

- Lake trout have a low priority on reproduction as they live a long time, but they are very vulnerable to over exploitation.

- Some lake trout are adapted to stream as well as lake spawning.

- In small lakes spawning areas and temperature are key issues.

- Lake trout in Teslin Lake do not favor cold water i.e. 4-5 °C in summer but use shallow 10-12 °C waters.

- In Nisutlin River near Teslin fish are at the "mud line" and concentrated in one area.

- Lake trout at Atlin occupy glacial waters and can be white in color – adapted to living in sedimented waters.

- Main factors re lake trout are over exploitation/competition with exotics and contaminants (i.e. other stressors).

- Arctic grayling are adaptive, and must be so as their habitat is subject to change e.g. by beaver dams.

- Regarding temperature, fish do find microhabitats within lakes by which to survive. (e.g. kokanee were transferred to a seemingly inhospitable lake but survived).

- Management of salmon by permitting 80-90% exploitation and 10% to spawning grounds does not safeguard populations for the vagaries of environmental change.

The seeming over-abundance years are nature's insurance against years of poor recruitment.

- Lake whitefish (Aishihik Lake) and cisco are sensitive to water level changes.
- Critical habitat is necessary for recruitment, growth, and survival of life cycle stages.
- Large lakes likely have good diversity of habitat (balance between shoreline depth and temperature 9-12 °C), small lakes less so.
- How to decide re loss of a lake: reduce risk through knowledge, but ensure the precautionary approach is applied to that which is saved within the watershed. That is, protect from stressors that which is left. Prevent loss of adaptive diversity.
- With regard to eliminating lakes, loss of genetic adaptive diversity must be a consideration.
- Could assess genetic diversity to see if fish are distinctly different.
- Morphometric characteristics of fish reveal differences among populations.
- *1970s workshop (CJFAS) Salmonid communities in oligotrophic lakes (deals with exploitation, exotics and habitat alteration).*

Indicators for habitat value, monitoring stream health and recovery, and productive capacity with particular reference to the Yukon and placer mining

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1. Habitat value indicators for unimpacted areas:

- Office based: stream gradient
  - Fish data and geomorphological considerations suggest stream gradient is a useful broad measure of productive capacity.
  - But, maps may not have adequate resolution, unclear how applicable the method is to large rivers.
- Field based: physical habitat surveys
  - Survey substrate condition, pool frequency and size, woody debris and other measured to provide detailed local information.
  - But, expensive, time consuming. Studies must be carefully designed to overcome well-known technical limitation.

2. Indicators for assessing habitat impacts:

- Office based: Land cover and land-use alterations
    - Experience in other jurisdictions suggests quantitative measures of land use alteration can be used to evaluate stream health and in some cases fish production. Analysis of sequential air photo series allows for evaluation of past and future trends. Measures could include area of forest cover removed, riparian disturbance, road density, etc.
    - But: land-use impact indices are surrogates for how might upslope processes be modified and are not a direct measure of stream status. Point-source pollutants may not be captured.
- Field based: Benthic macroinvertebrates
    - An integrative measure of stream health: well used, easy to sample, and with standardized techniques. Demonstrated to be sensitive to present-day and historic placer mining impacts in the Yukon.
    - Best as an indicator of the cumulative impact of elevated sediment levels, and rates of recovery upon cessation of inputs. Not likely as sensitive to changes in stream habitat structure, riparian condition and wood inputs that might also be important for fish production.
- Field based: Physical habitat assessment.
    - As in (1) above – direct measurement of stream channel attributes for comparison with "reference" (unimpacted) conditions.
    - Quantitative assessment requires substantial effort.

Potential tasks to determine the feasibility of stream health value and impact assessment measures

1. From GIS system determine if gradient analysis is a useful tool for classifying fish habitat potential with adequate resolution. Using pilot or test basins, ground truth results from field data or local knowledge.
2. Evaluate the scale and scope of land use alteration from placer mining from series of air photos to establish potential metrics that are relevant and can be measured and compared over space and time.
3. Examine the EC invertebrate database in more detail to provide estimates of the variability among samples, the required taxonomic resolution and other technical issues. Match invertebrate data with GIS estimates of landscape alteration to

evaluate various indicator metrics or species for their utility to evaluate land use impacts.

4. Ground truth restoration and recovery rates by comparing changes in land cover from air photos to stream habitat metrics (from field studies) to establish time frames for stream and watershed recovery.

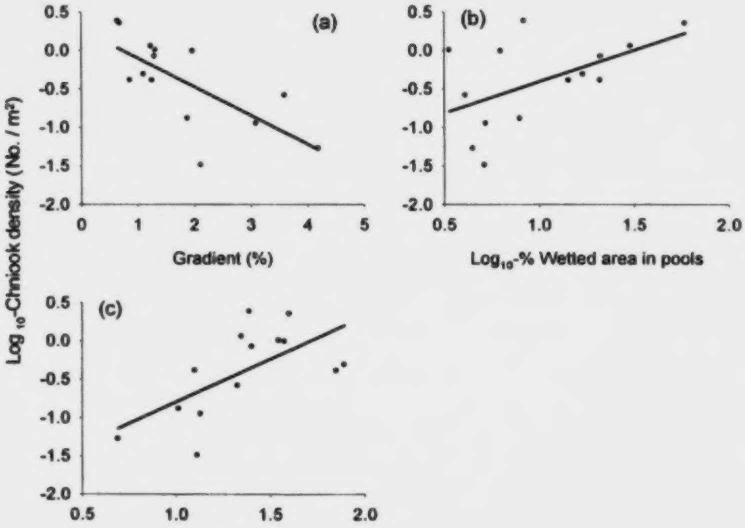
Options for stream health monitoring and indexing: background material

1. Evaluating the potential productive capacity of (largely) unimpacted small streams.

- The potential of stream habitat to produce fish will depend on the valley form and the combined influences of water, sediment and vegetation (Montgomery and Buffington 1998). In this section stream gradient is proposed as a simple measure of the productive capacity of segments of small streams. The approach is similar to the channel classification scheme of Montgomery and Buffington (1998).

  For juvenile chinook salmon recent research suggests the geomorphologic processes that create good habitat (pools, cover, woody debris, Bradford et al. 2001) are partially driven by stream gradient. Mossop (2003) measured many aspects of small stream habitat and found correlations with fish abundance. The habitat measures were correlated with each other, and with stream gradient (see figure below). Thus stream gradient appears to be a useful map-based measure for predicting the productive capacity of small streams. Note that the predictions from gradient are only "order of magnitude" as local conditions will have an important influence.

  The situation is less certain for grayling. Studies in Alaska show that juvenile grayling are more likely to be found in low gradient reaches in the downstream areas of a basin, whereas large adults are found in headwater areas which they use for feeding in the summer (Vascotto and Morrow 1973; Hughes and Reynolds 1994). Grayling prefer pools where they sight feed on drifting insects. Data in Hughes and Reynolds (1994) show that adult grayling abundance decreases in headwater areas,



mainly because pools become less frequent in higher gradient areas. Thus it seems reasonable to use gradient in a similar way for grayling as for juvenile chinook salmon.

The regression equation for (a) above is: Log_{10} (fish density $\#/m^2$) = 0.28 – 0.37 (gradient, %).

As an example the model predicts densities of 0.81 fish/m^2 in a stream with 1% gradient, and 0.06 fish/m^2 in a 4% gradient stream.

From these predictions, a rating scheme based on gradient could be formulated. The following is an example: the number of categories and their boundaries can easily be modified. The boundaries proposed correspond to the ranges noted by Montgomery and Buffington (1998) for delineating reach morphologies.

Gradient class (%)	**Rating**	**Predicted chinook density**	**Likely reach morphology**
0-1.5	Good	$0.53\text{-}1.9\cdot m^{-2}$	Pool-riffle: abundant pools and LWD
1.5-3.5	Fair	$0.10\text{-}0.53\cdot m^{-2}$	Plane-bed: fewer pools, more glides
3.5 +	Limited	$<0.10\cdot m^{-2}$	Step-pool, cascade: scarce good habitat

- **Implementation**

  Gradient can be measured remotely using GIS. If elevation data is at the 30 m contour interval found on 1:50,000 maps then the resolution of reaches will be at the multi-kilometre scale.

  This method will likely be most useful for evaluating habitat of tributary streams to separate those that are steep mountain streams from those that might have more low-gradient habitat in the downstream reaches. It is unclear if this method can be used to "roll up" habitat classes in large basins. The proportions of the various classes might be quite similar across basins, as each will have a certain amount of steep, moderate and low gradient channel, especially within areas of similar geological history.

2. Estimating "health" or "condition" of impacted streams

- This section considers the task of estimating the likely health of streams across a large area that might be impacted by different types and intensities of human activities. The desire is to develop an index to compare/rate/rank streams with respect to the overall impact.

Channel Assessment

- Traditional stream channel assessment uses physical measures such as width, depth, pool/riffle measurements, status of riparian habitats, bank stability, substrate condition and others. There are challenges with using these measures to evaluate stream health because they are all highly variable in natural, pristine systems, and are often difficult to measure systematically. These issues are discussed in Bauer and Ralph (1999). In addition, these measures are really only the symptoms of larger issues that are usually impacting the whole basin.

Invertebrates

- Considerable attention has been focused on the use of biotic diversity to measure stream health. This approach often takes the form of indices of the diversity of stream macroinvertebrates or constructed metrics based on the presence or absence of taxa that are tolerant or sensitive to human impacts. The latter is the so-called "Index of Biotic Integrity" (IBI) that is used in many states for monitoring stream health for the *Clean Water Act* (Karr 1998). IBI approaches are particularly useful for water quality issues where changes to stream health may not be readily apparent from evaluations of physical habitat or catchment land-use patterns.

- Numerous studies have identified relations between invertebrate abundance and diversity and placer mining. Findings have included simple dichotomous comparisons (mined/unmined; Wagener and LaPerriere 1985), inverse correlations between invertebrate abundance and suspended sediment levels (Seakem 1992), and the effects of historical mining on present day invertebrate abundance (Kennedy 1995; Bailey et al. 1998). In addition, there is a large database of invertebrate samples that has been collected by EC from which summary statistics were generated by Don Toews. Other workers have also identified changes in invertebrate communities with increases in suspended or deposited sediment (e.g. Zweig and Rabeni 2001; Relyea et al. 2000). Collectively, these results suggest that stream invertebrates could be used as a monitoring tool to assess the impacts of mining, or evaluate recovery from mining.

- Invertebrate diversity and abundance may be useful as a long-term monitoring tool for evaluating stream health changes as a result of impacts or recovery. It must be realized that there will always be considerable variability in the results of an invertebrate sampling program, and a time series of data for a single stream will be very noisy. Thus there will be a need to explicitly consider the "rules" for evaluating impact and recovery with respect to the intensity of sampling size of the effects, and the risks associated with decision making using imperfect data.

- The primary mechanism linking stream invertebrates and placer mining is suspended and deposited sediment. Therefore, invertebrates are unlikely to be a sensitive indicator of other attributes of fish habitat that might be affected by placer mining- such as riparian structure, LWD loading, channel morphology, etc.

- Sound streams between invertebrate IBI and the area "paved" (from Karr 1998).

- The corollary to this work is that stream health can be likely assessed by quantifying the human impacts on the landscape. Reductions in stream health often result from the changes in upslope processes which occur when the landscape is altered. Hence, quantifying and monitoring land use may be a useful index of the likely status and direction of change in stream habitat condition. Many measures have been used, including the proportion of forest altered in different ways, percent of land for other uses, road density, the number of stream crossings, length of road close to the stream and length of riparian disruption. Of course, these measures will not reflect additional impacts due to chemical pollutants.

Implementation

- Land-use impacts for watersheds can be evaluated with air-photo interpretation, and where possible should include a historical series to evaluate trends in the measures used. A test of the approach can be made by coupling the EC invertebrate database with the GIS/aerial photo data database to establish relations between invertebrate abundance and diversity and catchment properties and indices of disturbance.

- If predictive relations can be established (such as the index of biological integrity with the percent impervious area – shown above), there are a number of ways these might be used. First, these confirm the use of GIS-type attributes as predictors of stream health, which should allow the rapid assessment of all basins in the territory with respect to the degree of disturbance. Historical air photos may allow interpretation of potential lag effects caused by slow rates of recovery.

Other measures of stream health

- Various jurisdictions have developed more comprehensive monitoring and assessment protocols using additional characteristics related to the physical attributes of the channel such as abundance of pools, woody debris, riparian and substrate status, etc. This approach can provide direct information on physical aspects of the stream channel that invertebrates might also be able to do.

- Reference conditions are developed as ranges or averages based on extensive sampling of unimpacted streams. This approach can be challenging as state of a stream will not only depend on the human impact, but also the geomorphological and biological context for the stream. Issues such as natural sediment supply and transport capacity, riparian vegetation, hydrology and disturbance history will all affect channel condition. These issues are documented in Bauer and Ralph (1999) and Montgomery and MacDonald (2002).

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(NOTE: This was a preliminary review of stream health monitoring.)

The monitoring of stream health/recovery.

- Stream health monitoring usually consists of comparing attributes of the stream in question to:
    1. pre-impact conditions, although these are often not available,
    2. a reference condition (such as an unimpacted state), either as an average or range as determined from sampling or examination of similar streams in the region,
    3. predetermined desirable conditions, as a management objective potentially different from (2).

- A stream health monitoring program should carefully consider its goals, and on what basis decisions are going to be made, before getting into the details of what to measure.

- **Some attributes of stream health that might be considered are:**

    Watershed condition. Stream health depends on the status of the catchment with respect to land use. Detailed studies of stream health show that in-channel indicators (water quality, biotic diversity) usually vary linearly with measures of catchment disturbance, such as human population, road density, proportion of land in agriculture, forestry, urban development, or the percent impervious (i.e. paved) area. No thresholds have been defined. Therefore it is reasonable to assume that stream health will vary with land disturbance, and monitoring land use (air photo interpretation or similar) will be a useful measure of likely trends in stream status.

Riparian zone condition. The riparian zone provides many functions to small streams including:

a. Shade, although this may not be an issue in the Yukon
b. Organic material, as leaf litter and debris. This is an important source of energy, especially in the fall and early spring
c. Terrestrial insect drop, as a food source for fish
d. Large woody debris (LWD) which is a very important component of stream habitat structure both in providing cover, and as a pool-forming mechanism. We have recently documented the importance of LWD in small Yukon streams.
e. Land and bank stability – minimizing surface erosion from runoff, and bank erosion from higher flow events.
b. Riparian zone status can be assessed visually or quantitatively. Reference condition data can be obtained in the same manner.

Channel form. In small streams the channel form depends on the gradient, LWD supply and sediment supply relative to transport. In general, increased sediment supply and reduced LWD input will lead to a more homogenous stream channel bed, commonly called "ruffles." This will be most prevalent in lower gradient reaches where sediment transport is more limited. We have data on channel forms and LWD for reference and impacted streams.

Channel bed. Disequilibrium in sediment supply will lead to reduced grain size in the channel bed and infilling of interstitia. Channel bed condition can be monitored by a variety of means and compared to reference conditions.

Water quality and quantity. Suspended solid (SS) loads are often higher in watersheds with disturbed landscapes, and the removal of forest cover changes water yields and flood intensities. Water quality is straightforward to consider as SS, however, detecting changes in stream flow is very challenging.

Stream biota. Benthic invertebrates are often used as measures of stream health, and are commonly found to be linearly related to land use or disturbance measures. There is some experience in the McQuesten that suggests promise, as that work found some correlation between invertebrate diversity and time elapsed since the last exposure to placer mine effluent. Additional reference collections may be required to expand the geographic range (and possibly range of stream types). The EC database may be useful here. Generally very detailed and expensive taxonomic work is required because the indicators are based on species composition and diversity rather than simply abundance. The actual type of indicator chosen will depend to some degree on the management objective.

Fish. Fish present a great challenge. Fish diversity is used in more southerly locales, but the lack of a diverse native fish fauna in the Yukon suggests that diversity would not be useful measure. Whether there are "sentinel" species or not is unclear. In theory fish abundance could be used, but abundance, especially in headwater streams, will depend on factors unrelated to the condition of habitat in the study stream. These factors include the availability of "stock" downstream to colonize mined streams, especially if they have unreliable winter flows, access difficulties posed by beavers, ice conditions, windfall, etc., weather and climate factors such as extreme high or low flows. In addition, estimating abundance is technically challenging.

Freshwater Institute (FWI); Great Lakes Laboratory for Fisheries and Aquatic Sciences (GLLFAS):

Two meetings were held with Central and Arctic Science and Habitat staff in Winnipeg (Freshwater Institute) and Burlington (Great Lakes Laboratory for Fisheries and Aquatic Sciences). Attendees and staff who provided comments are identified here.

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Compensation and restoration

- Compensation has typically involved only physical habitat modification. There needs to be more assessment of the ability of habitat to augment fish populations by improving its carrying capacity. We need to know to what extent fish populations can be increased by habitat manipulation.

- Researchers in the north are dependent on industry's infrastructure. Some researchers (e.g. Nick Jones, University of Alberta; see Jones et al. 2003) have received tremendous co-operation from industry to study fish-habitat compensation issues (such as the Panda Diversion Channel at the Ekati mine). These researchers have had access to industry manpower and equipment, in addition to funding. However this dependency is related to DFO's approach to this kind of issue. There has been a reluctance at several government levels to introduce and support research regarding impacts of projects or types of projects it already has Environmental Assessments for.

- At the Diavik mine, effluent from the operation will double the nutrient content of Lac de Gras, which is 1000 km^2 in area. In such an oligotrophic location it is debatable whether that should be considered as a compensation measure because of the expected stimulation in biological productivity. Nutrient enrichment may disproportionately affect the delicate balance in simple northern ecosystems that have evolved under low nutrient loads. The value of any stimulation of biological productivity by increased nutrient inputs will be contingent on the nature and magnitude of the inputs, and on the capacity of the ecosystem to respond without imbalance. It is also important that the cumulative nature of impacts is recognized, as well as understanding that typically ecosystems are subjected to a multiple rather single stress scenario (e.g. nutrients added as ecosystem is also responding to warmer climate). However, any ecosystem-based approach requires substantial co-operation among federal departments.

- The lack of a fishery is not grounds for devaluing fish habitat. In northern Canada, remoteness is an issue – out of sight, out of mind. However, when flying over the areas (for example, the oil sands), the destruction of large portions of watersheds, is obvious. Therefore, ecological integrity of these watersheds is likely compromised.

- Fish habitat compensation is often evaluated on a local basis, and not usually at the watershed level (regarding the Diavik mine there was extensive study and workshop discussions of the project on the watershed level; meetings where held in Coppermine to deal with watershed issues for example). We could require industry to improve fish habitat assessment at the appropriate level and improve its compensation and restoration activities, but it has to be done where the initial damage to habitat occurred.

- DFO Science has argued for a quantification process for compensation because application of the "no net loss" policy requires it. Square metres of habitat for square metres of habitat is the simplest form of such compensation, but mining companies like to place a monetary value on habitat for accounting purposes. However, the greatest resistance to implementation of a habitat quantification process to ensure no net loss has come from DFO habitat managers. Consultants, hired by proponents and developers, dislike producing monitoring reports that may not be read. While they may like doing data analyses, there may be resistance to this from habitat managers. Some consultants often do such poor studies that the reports are of little value. Incidents have occurred when a DFO Science representative says this is the case, and "industry" has complained that we are not willing to read the reports. Also industry (and DFO Habitat) typically give Science staff too little time to review documents properly. It appears that in these circumstances that both industry and Fisheries habitat managers have difficulty understanding that there are unknowns associated with some questions and that professionals have issues with giving advice where there are so many variables to consider.

- At the Diavik mine, lakes are filled in because of cost of transportation of wastes. To compensate for the loss of these lakes the manipulation of the surrounding pristine landscape is considered as an option. Economic factors force us to keep our options flexible, but perhaps Canada should take a firmer position with diamond mines to ensure they clean up progressively as they develop their mines and fill a previous open pit with waste material from the next pit being mined.

- Northern Aboriginal communities have tended to resist fish habitat compensation measures by humans in pristine areas of the north. However, there are a number of factors that have affected how and to what extent Aboriginal communities will accept or not accept compensation plans. They include fundamental issues with their cultural beliefs, legal issues with land claims, and poor experiences in the past. If mining for diamonds and the inevitable changes to land and water are accepted, then perhaps enhancement measures should also be accepted in pristine areas to offset losses to fish habitat and fish caused by the mining development.

- Linked to this issue is a need to give more thought to the benefits to Aboriginal communities and any fisheries through fish habitat compensation measures that are associated with mining developments.

- At Diavik, three of the options for compensation were: join water bodies to create connectivity; 2) deepen water bodies for enhancement of over-wintering habitat; and

3) create littoral zones in lakes by using local rock. It is necessary to investigate what will result in successful compensation.

Productive capacity

- Use of the morphoedaphic index (MEI) concept for assessing fish production may not be applicable in northern areas because of the lack of precision. It is an empirical description using a group of values. The available data encompass differences among lakes of orders of magnitude, and there will not be many data points for northern Canada. (Fish yield versus lake depth is probably a logarithmic relationship and not a linear function). The MEI was developed for large, temperate lakes that typically are exploited (commercial or angling) for fish (i.e. yield is the response variable in the model). To extrapolate this MEI model to shallow sub-arctic lakes may be tenuous, unless the model was calibrated and validated for these areas. It should be noted that MEI was not a good predictor of primary or secondary production in recent reviews of fish production in lakes (Downing et al. 1990; Downing and Plante 1993). Rather, fish production in lakes was significantly related to phosphorus, primary production and water temperature. With the appropriate data (e.g. empirical relationships between salmonid production, lake phosphorus concentrations and temperature), first order predictions of productive capacity may be possible for northern lakes.

- In order to obtain the total fish biomass for each lake eliminated for diamond mining, the lakes were fished out. It was an instantaneous determination of production, and should provide 20 points on a graph because of the 20 lakes that have been eliminated. There is concern, however, about the usefulness of the data that were gathered which, if inferior, will not contribute significantly to rigorous scientific analysis.

- In addition to requiring information on production, we need to know more about the thermal regimes in these lakes. Temperature is a fundamental factor that controls and limits biological productivity. Lac de Gras has more thermal inertia than smaller lakes, and its relative contribution to production versus smaller lakes with different thermal regimes could be substantial. The MEI requires a proper population estimate, but there is no reason for any specific mine to conduct that sort of analysis, and far better that an aggregation of mines and others do such work. (Propend was to have collected information about the limnology of many of the lakes affected by the Diavik project but they did not do the work because of scheduling issues and decisions by DFO).

- GIS data on lake area would be a good predictor of potential production (kg) if it were possible to obtain. The mines do basic resource mapping, but it is generally not available to the public. Survey data from the mines would be very useful to us. For example, the lake inventory information around mines is proprietary, or perhaps consultants keep it so that they may use/sell it again. Thus the broader interest is denied.

- Sharing of information is clearly an issue that needs to be addressed. Collection of proprietary environmental information in the north does Canada little good, especially as Canada's federal science capacity continues to wither. Certainly it would be of benefit for federal researchers to be more involved in the design of the data gathering strategies to ensure that the data can be used to generate information that will be useful for regulatory and planning purposes. Ideally there would be some mechanism for industries to support federal research that did not create the potential for appearance of conflicts of interest if Canada's support for federal science is to continue to diminish.

- One strategy that might accelerate the future production of information useful for understanding northern aquatic ecosystems would be to match northern study ecosystems with southern studies (e.g. at the Experimental Lakes Area, ELA) in order to assess what "southern" information is transferable. For example, transfer of ELA knowledge was helpful in designing and understanding results of the experimental studies in the Saqvaqjuac lakes of northern Manitoba. Although there is discussion of doing this for indices, it would likely be valuable to also do this for the study of aquatic ecosystems.

- The data that mines have collected include lake morphometry, nutrient concentrations, and, for fish, size, age, and species. At Diavik, the company surveyed 30 to 40 lakes, but the data are not in any accessible report. We need to know more about fish life history, and one approach to obtaining that kind of information is through a consortium that facilitates data sharing.

- A habitat management plan pre-supposes that there are fisheries objectives for this area. However, we rarely get beyond the exploitation objectives of users. A habitat management plan is a plan to conserve, and to meet fisheries management objectives. We are not trying to save every vestige of the habitat in the face of development and get 1:1 replacement for that which is lost. For example, if grayling and charr have the greatest value (within fisheries plans), and fewer sculpins would result, maybe that would be acceptable if it addressed and contributed to regional fisheries management objectives for charr.

- At Diavik the habitat compensation plan included all fish species. A proportional composition table of species was developed and it addressed DFO objectives. DFO needs to articulate fisheries objectives for industry. It is DFO's responsibility to develop fishery targets, with species and numbers, with a view to protecting stocks into the future. Problematic to issues in northern Canada is shared responsibilities with land claims groups or Aboriginal organizations. The fundamentals of what is a fisheries management plan and what is a habitat management plan can vary among these partners. In the case of some settled claims, legislation related to the claim and co-management may dictate DFO's response.

- Where there are administrative agreements to manage the fishery, provincial partners need to be included in decision making. However, a Federal Minister remains accountable under the *Fisheries Act*. For example, section 36 is DOE's responsibility. Land claims and land claims partners are more of an issue in the north than provincial partners. Most claims include clauses that ensure the land claims legislation as it pertains to fisheries and management issues takes precedence over other government legislation, existing or proposed.

- In the Great Lakes, predictive littoral habitat-fish biomass models have been developed (Randall). Similar methods could not be developed for the northern lakes because empirical data are not available. A large database is needed to develop empirical models of fish-habitat linkages. Some of the methodology used in the south by Burlington scientists may be applicable to the north in future.

- Literature reviews done by DFO's Jim Reist show the paucity of data for the north in terms of how fish use their environment. Our knowledge of habitat use *in situ* is minimal. Reist's work on bull trout has doubled the amount of knowledge that we had.

Habitat suitability indices and models

- Habitat Suitability Indices (HSI) that were developed in the south are not generally applicable in the north. HSI assign relative values to different habitats, but they would not provide kg/ha of production from Lac de Gras, for example. However, they do allow us to determine which habitat is more suitable than another. HSI must be used on the ground by experts who can calibrate the indices. *At Ekati, the habitat suitability model was simple, and Diavik developed one independently (the two models were almost identical).* We need a consensus on the habitat requirements for lake trout and charr north of 60 to standardize these models.

- There is a need for better validation of HSI. The Minns' suitability model is seen as a simple first step. People should feel challenged to overtake it, but so far no one has. It was designed as a first-order analysis, that is, as a way to evaluate habitat on a quantitative (square metre) basis. *Randall's fish biomass – littoral habitat model for the Great Lakes could be recast as a habitat suitability model. Uncertainty is easily added* – it is on our website, but the software is not publicly available because the local habitat managers have concern over consultants obtaining it. However, the quality of decision making would improve if consultants were able to use the software.

- For the larger lake systems, the production in kg/ha can be developed. *Nick Jones compared the Panda Diversion Channel to 3 or 4 natural channels, and did a literature assessment.* One can do a first order assessment, but there is always the likelihood of a "bottleneck" that complicates analysis. Historically such a factor was assumed to be spawning habitat, but a spawning "bottleneck" in a lake is highly unlikely. *In Lac de Gras a shortage of spawning shoals for lake trout will not be an issue limiting their production.*

- Diamond mines have established unique circumstances in northern lakes. For example, with respect to the discharges of nutrient-enriched waters that may attract fish.

- A straight habitat analysis with our model (Minns' Defensible Methods) is the first stage followed by DFO research on, for example, finding thresholds in terms of "bottlenecks," and the rate of change of habitat before it becomes catastrophic change with serious implications to fish production.

How fish use their habitats

- Considering the fidelity of fish to their habitats, there are functional and obligate issues. There are more habitat use options for fish in lakes than in streams, so fidelity is more a functional than obligatory issue in lakes. *Ken Mills' work at the Experimental Lakes Area (Lake 373) was in relation to two small spawning areas, 22 m^2 in size. However, there is 100 times that much spawning habitat area in the lake, so the likelihood of problems re fish production is unlikely if these small areas were fenced off, for the fish would probably spawn elsewhere.*

- Suppose that the growth environment for young of the year fish is limiting. If there were a reduction of egg hatching success, recruitment would potentially stay the same. How fish use their habitats is a fundamental question for DFO and long-term studies are required to provide answers.

- Concerning the littoral zone in shallow northern lakes, it is ice covered for 8-10 months a year. The assumption is that such zones are not as productive as adjacent slightly deeper habitats in the open water period. The productivity of these northern littoral zones is very different than in the south where ice cover is less of a factor. However, it is possible that there are compensatory forces at play. Clearly this is an area for research.

- *A paper in CJFAS in summer 2003 relates to this discussion and the productivity of lakes (Flanagan et al. 2003). The relationships change with progression northwards. If the lakes are stratified, the fish are not confined to the hypolimnion. Lake trout evolved to select different thermal regimes – and this adaptation changes with northward progression.*

Fish Communities and Genetics

- How genetically isolated are populations? Are populations unique?

- A better geographic understanding of genetic uniqueness will alter one's perspective. The barrens' waters are highly interconnected, but phenotypic adaptation may also be operating with genotypic changes.

- In the Lac de Gras area, 10% of the lakes are fish-less, but these lakes could provide food and space for fish. They are fish-less either because they freeze to the bottom, or because they are inaccessible (no migration or connection corridors).

- Compensation efforts should be directed at improving access for fish to such currently fish-less lakes.

Climate change, cumulative effects

- Concerning the sulfur-bearing waste rock at Ekati, under what scenario would it remain frozen indefinitely, considering climate change? What contaminants might be released?

- It is predicted that the central barrens will get warmer with climate change. Diavik included only a brief comment on climate change in its environmental assessment. As possible evidence of subtle changes, ice roads do not last as long as they did some years ago.

- It might be that a development would stress the environment, but not collapse it. But, because of the cumulative impacts of stress, climate change could result in additional stress with adverse consequences.

- Cumulative effects are the most difficult to address, especially on a large watershed basis. We really have no idea about cumulative effects in the north. *For example, what will be the effects of the doubling of the nutrient levels in Lac de Gras on the Coppermine River, and downstream to the ocean?*

Monitoring and Research

- Industry is developing volumes of monitoring data, and each portion could be valuable over time. However, because agencies and industry sometimes have strained relationships, the information may not be widely broadcast, and it is possible that independent groups will do their own analysis (such as fishermen conducting their own assessments of stocks before dealing with DFO fisheries managers). It is important to recognize that low (very low) quality monitoring data may be supplied by industry because they are not required to do good science-based work. *(Many aspects of Diavik's monitoring are good examples of this type of effort or lack thereof).*

- DFO could request raw data before HADDs are authorized. If the data are proprietary, we could ensure the information is kept internal. It would be better though if the data were put on a public registry to avoid the inference of a strong linkage or partnership with industry. The provision of data could be made a condition of a HADD authorization (the US Food and Drug Administration requires the provision of raw data before drugs are registered).

- With respect to most compliance monitoring reports, nothing is done with them from an analytical perspective. Current monitoring requirements that are attached to authorizations and licenses are of limited value. There needs to be two types of monitoring: 1) alarm bell monitoring; and 2) monitoring to test assumptions of a hypothesis of effect, for example, blasting effects on spawning success and egg development (*University of Alberta-Diavik*). Habitat monitoring should consist of data collection, using control sites, as, *for example, the Panda Diversion Channel research (BHP Billiton) – a scientifically-designed program.*

- Concerning the oil sands industry at Fort McMurray, industry funds research and is, therefore, in control of these activities. Agencies do not fund the work and therefore they have no accountability.

- Habitat Management needs advice from DFO Science to direct industry on what data to collect and for what purpose.

- *In medical research for drug development, oversight protocols are developed by government. Regulatory bodies oversee experimental design.* DFO requires a mechanism and the appropriate expertise to get experimental design and replication right, so that the results of the work will withstand rigorous scrutiny.

- Diamond mining companies have offered to bring DFO and/or consultants together for advice on the design of monitoring and research, however, most environmental consultants may not be appropriately staffed to provide this advice. There needs to be a commitment by industry and others to address this issue. This fact supports the need for the greater use of models, such as those used for chemistry and water budgets. Biological information may be anecdotal, and hence DFO needs to address this deficiency and integrate data into models.

- Monitoring will be over 25 years or more at diamond mines, so there needs to be an adaptive approach during this time. DFO could play a significant role here in better explaining its needs and objectives so that the monitoring may be done more efficiently and be most relevant.

- The interpretation of data is important, and especially that which is related to understanding how productivity occurs. For example, biomass may be constant within a lake but fish size may be decreasing. There is a core connection between production and habitat that needs to be understood.

- Long-term studies are required (20 to 30 years). Some fish in northern lakes are 30+ years old, and in order to understand fish production, studies should be commensurate with the longevity of the species. Thus, DFO management's short-term requirements will be at odds with what research is required in order to answer some of the habitat-fish production questions relating to northern Canada.

- Mining is long term, so the duration of the damage to habitat needs to be comparable to the time taken to examine the consequences of this damage. However, short-term projects should be undertaken to produce products that have progressive value over time.

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CONDENSED AND CATEGORIZED CONSULTATION COMMENTS

The following comments were abstracted from the original text from the consultations and grouped into 14 topic areas. The information includes the origination of the comments to provide an audit trail for the abstraction process. These comments were later amalgamated with comments from the published literature and presented in the report by Birtwell et al. (2005*a*). This was a step towards identifying information deficiencies and recommending management and scientific needs for decision making over the loss and degradation of aquatic habitat in Canada.

LEGEND

Comments attributable to people who were consulted have been identified in the following text by their name or affiliate company as depicted in bold type.

BHP Billiton: Allison Armstrong, Jane M. Howe, François Landry, Jayda Robillard
De Beers: Robin Johnstone
Diavik: Gord Macdonald
Klondike Placer Miners' Association: Mike McDougal, Tara Christie
Canadian Natural Resources Limited: Calvin Duane
Suncor: Chris Fordham
Albian: Darrell Martindale
Golder: John R. Gulley, David A. Fernet
Miles: Mike Miles, M. Miles and Associates Limited

Johansen: Jeff Johansen, DFO, Pacific Region, Habitat Management
von Finster: Al von Finster, DFO, Pacific Region, Yukon Area, Habitat Management
Dahl: Julie Dahl, DFO, Central and Arctic Region, Western Arctic Area, Habitat Management
Shamess and Majewski: Jennifer Shamess and Dorthy Majewski, DFO, Central and Arctic Region, Prairies Area, Habitat Management
Gordanier and Moggy: Tania Gordanier and Derrick Moggy, DFO, Central and Arctic Region, Eastern Arctic Area, Habitat Management
Merkowsky: Alan Merkowsky, DFO, Central and Arctic Region, Prairies Area, Habitat Management
Rudolph and DeBruyn: Richard Rudolph and Ed DeBruyn, DFO, Central and Arctic Region, Ontario-Great Lakes Area, Habitat Management
Bérubé: Sophie Bérubé, DFO, Quebec Region, Habitat Management
Grant and Dawe: Carole G.J. Grant and Mary B. Dawe, DFO, Newfoundland Region, Habitat Management
Quigley and Harper: Jason Quigley and David Harper, DFO Pacific Region and National Headquarters, Habitat Management
Pacholek: Paula Pacholek, Northern Ecosystems Initiative, Environment Canada
Isabelle: André Isabelle, Director, Environment and Natural Resources Division, Natural Sciences and Engineering Research Council of Canada (NSERC)
Hartman: Gordon F. Hartman, habitat scientist
Bergmann: Marty Bergmann, DFO, Director, Arctic Science Program Development
Dick: Terry Dick, NSERC Northern Research Chair
Johnson: Lionel Johnson, Arctic ecologist
Levings: Colin Levings, DFO, Pacific Region, research scientist
McCart: Peter J. McCart, Arctic ecologist
Liber: Karsten Liber, Director, Toxicology Centre, University of Saskatchewan
Toews: Don Toews, Chief of Fisheries, Yukon Territorial Government
Bradford: Mike Bradford, DFO Pacific Region, research scientist
GLLFAS and FWI: Central and Arctic Science and Habitat Management (Great Lakes Laboratory for Fisheries and Aquatic Sciences, Burlington; Freshwater Institute, Winnipeg) – Susan Doka, Marten Koops, Ken H. Mills, Ken Minns, Michael Papst, Bob Randall, Mike Whittle, Michael A. Turner, Terence Shortt – Science; Chris Katopodis, Richard Gervais – Habitat Management

Main topic areas

1. Biology and ecology of northern and remote aquatic ecosystems

BHP Billiton-We believe research is important – if we do not understand how northern species use lakes and streams, we cannot answer fundamental questions.

BHP Billiton-We need to improve our understanding of the use of un-impacted streams by fish species. One area of research that could be focused on by the government is studying the ecology of un-impacted streams in the north. Research should also be conducted on "untouched" lakes. Both streams and lakes, however, have equal value from a research perspective.

De Beers-Site specificity is a problem and baseline information is needed.

Diavik-The company's Environmental Assessment scoped the fish and water quality issues regarding the Diavik mine.

Diavik-Fidelity to spawning grounds is a high priority topic for some. Basic biology for northern species is not well understood. There is also a need to focus upon quantifying the value of habitat, which then feeds into the consequences of the loss due to development. With respect to data gaps, there is the issue of habitat loss. "We" have weak tools to assess habitat loss. But we do not have enough information about fish in this region.

Miles-There is still a lack of basic biological knowledge regarding how fish use the northern environment. In the Mayo area there is off-channel habitat but not enough is known about fish movement to assist in the design and implementation of such features. Groundwater that can feed such areas would be very cold or non-existent in the north, so information is needed regarding fish use and movement to and within these areas. If one does not know how fish use these areas how does one design for compensation?

Miles-Need to assess factors that relate to habitat use – basically a definition of characteristics to identify the site requirements.

Miles-Basic scientific research is required to address ecological effects. Streams that are small behave differently than, for example, the Coppermine River. There is little or no information on discharge data; small stream data are important. Often peak flows occur when channels are ice filled. It is very difficult to design channels because the appropriate data are not available. So, movement of barriers to permit fish access is probably more likely to be successful as a compensation technique than creating small streams. "It is possible to make more bedrooms, but can you make more kitchens?" Fidelity to sites is a topic for study.

von Finster-Not much is known about population dynamics or how fish utilize habitat.

von Finster-So you find high and low extremes in numbers of grayling in certain habitats – but we have no idea of long-range populations in a stream.

von Finster-More needs to be done to determine information gaps, and what the priorities may be for studies, investigations, etc. to address the gaps. A workshop should be held with practitioners and Science to explore this. Temperature is critical – food depends on it.

von Finster-In terms of nutrients, in Yukon placer areas the rock is mostly sedimentary or metamorphic, which results in runoff that can be high in total dissolved solids, leading to high primary productivity. It is different from Pacific coastal areas, or the Northwest Territories.

von Finster-We should not be looking at understanding the life histories of fish as part of a before/during/after study.

von Finster-We should set up a research watershed where there is no chance of mineral exploration. A study is needed on how fish operate in an undisturbed environment.

Dahl-What are habitat requirements between spawning and over wintering?

Shamess and Majewski-We do not understand the needs of the life stages of the fish species, the site-specific populations, and species assemblages well enough to make scientifically-sound decisions on the significance of existing habitat features and sites.

Shamess and Majewski-Link between trophic levels? Need to maintain these linkages in the replacement habitat and also need to confirm whether the fish we are interested in represent the trophic level we need and take into consideration their life stages. We need to define our information needs in terms of trophic interactions and habitat requirements of the life stages themselves.

Gordanier and Moggy-There are a number of knowledge gaps at this point. Primarily these relate to a lack of information on biology and habitat requirements for species in the Eastern Arctic.

Merkowsky-Gaps include habitat information for fish species in Saskatchewan. Specific habitat requirements for Saskatchewan fish species have not been well documented.

Grant and Dawe-There is a general lack of information pertaining to the lacustrine habitat requirements of many of the fish species in Newfoundland and Labrador. Consequently, much of the information used by HM staff during decision making is based on fish habitat utilization in similar geographical areas in Canada, the United States, and other countries in north temperate locations. Much of this information was derived from studies that involved sampling of specific habitats, rather than a range of habitats. Although most of our decisions are based on physical habitat features such as water depth, substrate type, and cover being utilized by various fish species, habitat use is not solely dependent on attributes of the physical environment.

Grant and Dawe-Lack of information on spatial and temporal variations in prey availability, interspecific interactions (e.g. competition and predation), and various environmental variables such as water quality may cause shifts in habitat utilization.

Hartman-Given the pace of northern industrial development there will be a need for a suite of inter-connected research activities. I will therefore consider two inter-dependent levels of research activity. Many industrial activities have multiple and cumulative impacts. It is necessary to carry out long-term studies with spatial and temporal controls.

It is necessary to monitor, before and during the operation. There is great scientific challenge in keeping such programs going long enough to generate understanding of how processes operate, and carrying out in-depth analysis of the data coming from them. Complex, long-term process studies may not be possible for financial or other reasons. If this is the case, studies that examine separate elements within a system undergoing impacts may be the only option.

Hartman-Detailed life history information, at a local level, may not be well developed for many species.

Hartman-The research should be carried out soon, so that, as much as possible, information can be applied to ongoing planning and management, rather than appearing as historical documentation of ecosystem damage and loss. There is no excuse for anything less.

Hartman-Fish protection will be fitted in if possible, and as cheaply as possible. The inadequate funding of DFO research and staffing are testimony to this. I believe the departmental goals are becoming perceived by society as: "Playing a role in industrial development and job creation, and accommodating the protection of fisheries values to the extent that they don't cost too much or prevent development."

Hartman-There are needs for more than catchy "administrative pathway systems" in northern management. They are: sound science, development of field experience, staff continuity and overall commitment to the resource.

Hartman-As a postscript to these comments, I point out that DFO has abandoned essentially all fish-forestry research in BC. A host of new developments is taking place in the province, and we are not being prepared for them.

Bergmann-Research is needed to increase scientific knowledge relating to oil and gas exploration and development including construction aspects that can directly impact on fish habitat. Scientists are working with the oil and gas industry and in consultation with communities and other government departments (e.g. INAC) on proposals to address information needs in the Arctic. The question is do we have enough baseline information on fisheries in northern Canada? More fundamental information seems to be needed. Sediment effects at the fish population and individual level need to be considered. Lake draw-down is a major issue. We do not have a good understanding of seismic and its impacts.

Johnson-There has been little research carried out on species of fish and their habitat in northern Canada relative to that undertaken in more southern areas. There is a need for basic limnological research programs to be undertaken in regions that are not disturbed by human activities to address questions around lake morphometry and productivity, the morphoedaphic index, and productivity of lakes in relation to thermal regimes. Even under ice cover there is algal production, but we need to know what lake conditions are at this time of the year.

Johnson-Regarding lake trout in Arctic lakes, virtually nothing is known about the underyearlings. There is information on spawning areas that are easy to determine, but because spawning may not be each year, mistakes can be made regarding the use of these areas. Adults require critical conditions before spawning (a food-habitat issue). The survival of juveniles over winter could affect population structure when space is limiting.

Johnson-Arctic ecosystems are always subjected to extreme stress and they have become resilient over a number of years through meeting these conditions. The productivity of Arctic lakes will always be low so one should decide what "we" are managing for. Where populations of fish are fished there could be a problem of sustaining the fish community of the lake.

Johnson-There is a need for fundamental limnological studies in the Arctic to be carried out over significant periods of time. This work is very difficult to carry out, and it requires a commitment to long-term research. Such studies are needed on unperturbed (by humans) systems to provide baseline information. Over the shorter-term, surveys of primary production, benthos and fish should occur. The productivity of the littoral zones of Arctic lakes (studies when the areas are ice free and also under ice) and their use as a refuge for juvenile fish should also be studied.

"The most suitable starting point in the investigation of complex systems is the simplest system available which contains all the parameters of interest. The investigation should be planned in such a way as to allow the development of strong inferences which may then be tested in more complex systems" (Platt 1964, cited by Johnson 2002).

Levings-Lack of program research is a limiting factor for DFO scientists and managers trying to implement policy in the north. The lack of support for long-term ecological research is of course systemic in Canada but for northern Canada with likely decade-scale ecological responses to environmental perturbations it is particularly important. I would strongly recommend that DFO try to set up an LTER-like tundra network [US National Science Foundation Long-Term Ecological Research] involving other agencies such as EC, NRCan, and the universities. Another factor may be the perceived non-charismatic nature of tundra fish. The problem may be a lack of profile of the impact of diamond mining.

Levings-With respect to future research I think it would be most important to set up some long-term experiments that provide detailed comparisons between natural and developed habitats (I assume these would be lakes dug out of the tundra) to compare the ecological functions. This work should be done before this kind of compensation is accepted by DFO. In addition to classical food web and survival studies, stable isotope analysis of fish tissue could be used to help determine if the carbon pathways from phytoplankton production or from shoreline vegetation (detritus) are functioning in the same way. This technique might be able to provide some answers of ecological function in a time frame of 5-10 years.

McCart-Research is required to understand the implications of increases in total dissolved solids (TDS) at various levels of biological organization. More research is required on what controls populations of fish in Arctic lakes. In order to examine the effects of habitat change on fish, the species to study should be chosen wisely. The habitat requirements of fish in Arctic lakes need to be determined. Assumptions of "habitat values" for these fish have primarily been derived from information generated in warmer locations and, therefore, are not necessarily appropriate to use. Rather than relying on water quality guidelines when assessing the acceptability of changes in water quality characteristics, studies of effects should be done at operating northern mines.

Liber-Regarding diamond mining, research showed that during the first two years of operation of the mine, surface water quality changed significantly in Cell E of the Long Lake Containment Facility (LLCF) as a result of effluent discharges to Cells B and C (seepage through the dykes). Although these increases and levels may appear small, and the overall metal concentrations are still below toxic thresholds, these increases occurred over only a two-year period. Over time, these increases could result in species shifts in the invertebrate, especially macrozooplankton, community and thus in the food base for juvenile fishes. Evaluation of zooplankton populations in Cell E suggested that the early stages of change had already begun with soft-water, low pH adapted species such as *Holopedium gibberum* already beginning to show population decreases. If metal concentrations continue to increase at the initial rate, there could also be direct toxicity to sensitive species and life stages in years to come. Someone should be closely following the changes in water quality/chemistry downstream of the LLCF and assess the associated risk to the native aquatic community.

Toews-General comments regarding fish ecology: for whitefish in Aishihik Lake, littoral areas are very important for young of year fish. Lake trout exhibit straying within a population to exploit new areas and adapt to circumstances in their environment. Temperature is the most important habitat variable re ecology and behavior (Casselman's work) – lake trout need 10-12 °C water. Larger lake trout are piscivorous; smaller ones are insectivorous. Because of the importance of temperature, climate change is a significant issue, juveniles would be very vulnerable. Lake trout have a low priority on reproduction. Some lake trout are adapted to stream as well as lake spawning. In small lakes spawning areas and temperature are key issues. Lake trout in Teslin Lake do not favor cold water (i.e. 4-5 °C in summer) but use shallow 10-12 °C waters. Lake trout at Atlin occupy glacial waters and can be white in color – adapted to living in sedimented waters. Main factors re lake trout are over exploitation/competition with exotics and contaminants (i.e. other stressors). Arctic grayling are adaptive.

Toews-Regarding temperature, fish do find microhabitats within lakes by which to survive. Management of salmon by permitting 80-90% exploitation does not safeguard populations for the vagaries of environmental change. Lake whitefish (Aishihik Lake) and cisco are sensitive to water level changes. Critical habitat is necessary for recruitment, growth, and survival of life cycle stages. Large lakes likely have good diversity of habitat (balance between shoreline depth and temperature 9-12 °C), small lakes less so.

Toews-How to decide re loss of a lake: reduce risk through knowledge, but ensure the precautionary approach is applied to that which is saved within the watershed. That is, protect from stressors that which is left. Prevent loss of adaptive diversity. With regard to eliminating lakes, loss of genetic adaptive diversity must be a consideration. Could assess genetic diversity to see if fish are distinctly different. Morphometric characteristics of fish reveal differences among populations.

GLLFAS and FWI-One strategy that might accelerate the future production of information useful for understanding northern aquatic ecosystems would be to match northern study ecosystems with southern studies (e.g. at the Experimental Lakes Area).

GLLFAS and FWI-Concerning the littoral zone in shallow northern lakes, it is ice covered for 8-10 months a year. The assumption is that such zones are not as productive as adjacent slightly deeper habitats in the open-water period. The productivity of these northern littoral zones is very different than in the south where ice cover is less of a factor. However, it is possible that there are compensatory forces at play. Clearly this is an area for research.

GLLFAS and FWI-We need to know more about fish life history, and one approach to obtaining that kind of information is through a consortium that facilitates data sharing.

2. Linkages between fish and their habitats

De Beers-We must examine the key parts of habitat that are available – it is a functional issue.

Albian-Mineralized areas are where metal mines are located. A perfectly good stream could be naturally devoid of fish because of mineralization. Mine development does however speed up the erosion and mineralization of streams.

Albian-How little we know about the boreal forest. I am sure it is the same in the tundra.

Golder-Habitat is too often assumed to relate to fish production. The critical need is, therefore, to identify the "best" measures of habitat and the features of fish communities that are important.

Johansen-Habitat that has been identified as limiting will be the habitat of concern and may even be characterized as "critical" habitat.

von Finster-We do not know enough about fish movement. We do not know the population dynamics of the fish in streams. We do not understand how predators affect populations in these streams.

von Finster-One problem of northern fish species is that assessments are done by biologists for biologists. We need to integrate across disciplines.

Merkowsky-Habitat maps…for a few lakes in Saskatchewan…have been discontinued. This habitat mapping should then be followed up by studies to determine how the habitat is being utilized by fish for spawning, rearing, feeding, etc.

Grant and Dawe-Species of greatest concern are those that support commercial, recreational and/or Aboriginal fisheries. In the past, habitats of greatest concern were those providing spawning and/or rearing areas for species supporting commercial, recreational and/or Aboriginal fisheries. More recently, important over-wintering and/or summer refuge areas have also been taken into consideration for these same species.

Levings-The functions of various fish habitats are usually only understood generally, especially their interrelated roles. This conjures up the idea of "critical" fish habitat which has taken on a new emphasis since SARA has come to pass. However I think what is missing in the modern ecological context is the appreciation of the linkages between habitats.

GLLFAS and FWI-Literature reviews done by DFO's Jim Reist show the paucity of data for the north. Our knowledge of habitat use in situ is minimal.

GLLFAS and FWI-There are more habitat use options for fish in lakes than in streams, so fidelity is more a functional than obligatory issue in lakes. How fish use their habitats is a fundamental question for DFO and long-term studies are required to provide answers.

3. Measurements of productive capacity

Johansen-Note that when consideration is being given to whole lake destruction, the circumstance is actually the destruction of a whole ecosystem.

Dahl-In trying to achieve NNL, we are looking at a comprehensive approach: first we look at sunlight, water volume and then nutrient load. We must increase one to increase output.

Dahl-In order to protect habitat for forage fish, we place a value on foraging areas. They use spawning and nursery areas, but we need better definitions of these terms. To quantify fish loss, we ask the companies to do some exploratory netting. We use a bathymetric map and figure out where the fish concentrate. A proposed targeted approach for assessments is to focus on fewer species and life stages to make monitoring manageable. We should be targeting the most important species and life stages as measures of success. We assume crossover functionality of the habitat. Areas do not need to support all stages of all species.

Shamess and Majewski-We are using Habitat Units as a surrogate for productive capacity.

Shamess and Majewski-On projects of the magnitude proposed in the AOS [Alberta oil sands], the unknown contribution of non-sport fish cannot be discounted, nor can it be *accurately evaluated based on current information.*

Gordanier and Moggy-A modified Habitat Evaluation Procedure was used to determine the number of Habitat Units in the lake proposed for destruction. The same procedure was used to evaluate the proposed compensation areas such that losses and gains could be compared. Species of concern in the Eastern Arctic are primarily related to subsistence fisheries – fisheries most commonly impacted by whole lake loss proposals. Commercial fisheries are predominately marine in nature and to date there seems to be little development work affecting habitat for these species. Habitats of concern are typically spawning, nursery, rearing, migration and over-wintering habitat.

Merkowsky-These northern lakes are oligotrophic so their productivity will be limited by the availability of nutrients and it is not clear if spawning habitat is a limiting factor.

Bérubé-To assess large-area habitat losses (entire lakes), the Bradbury, Power and Roberge method is used (cf. "Standard Methods Guide for the classification/quantification of lacustrine habitat in Newfoundland and Labrador" DFO, NL, 60 p.) Quebec habitats that have ongoing mining operations are very similar to those covered in this guide. This method is also used (adapted) to determine the productive capacity of lakes currently being used as tailings impoundment areas (TIAs) and in respect of which an application would be filed for listing in Schedule 2 to the Metal Mining Effluent Regulations (MMER).

Bérubé-We lack knowledge of the productive capacity of the disturbed sites (productivity of the lakes already being used as TIAs); and the productivity of northern habitats.

Grant and Dawe-Information on the habitat requirements/preferences of various life stages of freshwater and anadromous/catadromous fishes occurring throughout Newfoundland and Labrador was compiled by Habitat Management (HM) staff and published as a DFO Manuscript Report entitled "Life history characteristics of freshwater and anadromous/catadromous fishes occurring throughout Newfoundland and Labrador, referred to as Bradbury et al. (1999).

Grant and Dawe-When assessing impacts on lake habitats, HM staff also determine what effects, if any, this will have on species inhabiting a lake's tributary streams. A system referred to as the Beak Consultants Ltd. (1980) habitat classification system is currently used by HM staff in this instance. However, this system was developed mainly for salmonids, specifically Atlantic salmon and brook trout, and is therefore limited in terms of its applicability to other, non-salmonid species. HM staff in the NL Region are currently developing a revised riverine habitat classification system to deal with an increased diversity of fish species.

Grant and Dawe-HM staff in the Newfoundland and Labrador (NL) Region then developed a guideline entitled "Standard Methods Guide for the classification/quantification of lacustrine habitat in Newfoundland and Labrador" referred to as Bradbury et al. (2001). To utilize this methodology the proponent must submit the following information on the lake, or section of lake, to be impacted: fish species present; substrate mapping; bathymetry; and vegetative cover. Information on various condition indices (e.g. nutrient availability, water quality parameters, lake morphometry, presence of contaminants, etc.) may also be provided as a means of reflecting fish habitat productivity.

Grant and Dawe-The two documents referenced above ["Life history characteristics of freshwater and anadromous/catadromous fishes occurring throughout Newfoundland and Labrador" Bradbury et al. (1999); "Standard Methods Guide for the classification/quantification of lacustrine habitat in Newfoundland and Labrador" Bradbury et al. (2001)] are used to classify/quantify fish habitat losses (and/or gains in the case of fish habitat compensation) in lakes and ponds. The basic underlying premise of this approach is that habitat is classified and quantified according to the extent by which it is utilized by various fish species and their different life stages. A key assumption is that the frequency with which a species utilizes a particular habitat provides a good indication of its importance and as such its contribution to fish productivity.

Levings-The problem of compensation for fish habitat loss has been plaguing DFO Science and managers since 1986. Part of the problem goes back (yet again) to the problem of measuring productivity capacity (PC). Habitat managers, of necessity, need relatively simple tools to measure loss of PC and compensation for same, and this is why areal measures (m^2) of surrogates such as marsh area, pond area, etc. are used. But as is well known, compensation will always involve a habitat switch because habitat cannot be created *de novo*. Some functions will always be traded off and implicitly species are traded off.

GLLFAS and FWI-Use of the morphoedaphic index (MEI) concept for assessing fish production may not be applicable in northern areas because of the lack of precision. To extrapolate this MEI model to shallow sub-arctic lakes may be tenuous, unless the model was calibrated and validated for these areas.

GLLFAS and FWI-With the appropriate data (e.g. empirical relationships between salmonid production, lake phosphorus concentrations and temperature), first order predictions of productive capacity may be possible for northern lakes. We need to know more about the thermal regimes in these lakes. Temperature is a fundamental factor that controls and limits biological productivity. The MEI requires a proper population estimate, but there is no reason for any specific mine to conduct that sort of analysis, and far better that an aggregation of mines and others do such work.

GLLFAS and FWI-GIS data on lake area would be a good predictor of potential production (kg) if it were possible to obtain. The lake inventory information around mines is proprietary. Sharing of information is clearly an issue that needs to be addressed.

GLLFAS and FWI-For the larger lake systems, the production in kg/ha can be developed.

4. Program research

BHP Billiton-We have approached DFO in the past to provide advice and input. We think that the link between DFO Habitat Management and Science in the north may be missing. We think that the science component is missing in the Arctic at DFO.

Klondike Placer Miners' Association-Research is being conducted by the Yukon Territorial Government. This research has documented important attributes in placer-mined streams not previously investigated.

Klondike Placer Miners' Association-We need both short term assessments to give comfort, but cannot ignore the 5 to 10-year term and the 20+ year term.

Klondike Placer Miners' Association-Updated research to evaluate the effectiveness of these regulatory changes would be useful to inform our new regime for placer mining and for understanding the effectiveness of the application of best practices for placer mining.

Canadian Natural Resources Limited-Clearly-focused research or development of acceptable methodology to assess and document what a HADD is and what is viable and acceptable compensation are the most outstanding items to oil sands development.

Canadian Natural Resources Limited-As the future oil sands developments expand, water will remain the highest priority and the area of most interest and need for assessment and analysis for authorization.

Suncor-One of our key issues is the difference between the levels of natural and anthropogenic chemicals within the natural environment (particularly the Athabasca River).

Golder-Other research areas that DFO may want to consider specifically in the oil sands region relate to the response and adaptability of the aquatic resource to petroleum hydrocarbons in its environment. In this context, the issues of fish tainting, and fish health risk assessment are worthy of further investigation.

von Finster-Science and practitioners need to get together to decide on tools. Science builds the tools, practitioners use them. A tool is a building block.

Shamess and Majewski-Need more information on groundwater/surface water interaction; and contaminant export and impact on surface waters.

Gordanier and Moggy-Regarding initiatives to fill gaps in knowledge and improve decision making, to our knowledge there are no initiatives underway.

Rudolph and DeBruyn-Information on historical and current fish/fish habitat data, mining technology and quantifying impacts associated with lake/large area losses and developing suitable compensation represent knowledge gaps.

Rudolph and DeBruyn-In Ontario very little research has been done recently which is directly related to loss of habitat and impacts to fish at the lake and watershed level. A considerable amount of research has been conducted in areas such as Cornwallis and Little Cornwallis Islands on impacts from mining on lakes.

Bérubé-The Science Sector in the Quebec Region does not conduct any research on freshwater ecosystems. DFO often requires proponents to monitor the impacts of their projects and the success of the habitat compensation measures they are required to implement. This helps to generate new information, but the usefulness of this new information in eliminating knowledge gaps remains limited.

Bérubé-To our knowledge, no specific initiatives are underway in Quebec to fill knowledge gaps, other than requests for information and follow ups made to proponents.

Grant and Dawe-The following initiatives are currently being undertaken by Science in an attempt to fill knowledge gaps and improve decision making regarding impacts to fish habitat: evaluating habitat surrogates of productive capacity of fish habitat through linking empirical measures of biomass and total production; evaluating habitat use and preferences for three co-existing anadromous salmonid species in Labrador; and investigating the effects of varied hydro-peaking regimes on Atlantic salmon survival and habitat use during the winter.

Bergmann-A series of seismic issues is being studied at various levels – biological, physiological, and behavioral. A great deal of work is required in order to make defensible recommendations. Central Agencies seem to believe that the Government of Canada does not need to do research in the Arctic concerning oil and gas. Industry would not investigate cumulative effects or climate change. Although we received only 35% of the requested funding for northern oil and gas, there are the funds to address some key scientific issues. There is also the issue of utilizing different materials for construction.

Bergmann-To be effective in supporting the requirement that the Arctic will be in the mainstream of Canada's economy, we will have to carry out scientific research and be prepared to work outside our typical "comfort zone": within DFO Habitat Management's regulatory role, with respect to concerns over oil, and regarding impacts on fish and fish habitat associated with construction and pipelines. Increased fishing pressure may change the dynamics of fisheries management even though we presently do not have the fundamental knowledge base about fish and fisheries in these areas.

Bergmann-Perhaps there are there better ways of understanding impacts in the Canadian north, it would be important to consider prey species in areas that freeze to the bottom. Energy (food) requirements are significant considerations in the typically cold and ultra-oligotrophic Arctic tundra environment. DFO cannot impose on industry the responsibility to do basic research on the issues mentioned here; the research must be a cooperative undertaking.

GLLFAS and FWI-Long-term studies are required: 20 to 30 years. DFO management's short-term requirements will be at odds with what research is required in order to answer some of the habitat-fish production questions relating to northern Canada. Mining is long term, so the duration of the damage to habitat needs to be comparable to the time taken to examine the consequences of this damage. However, short-term projects should be undertaken to produce products that have progressive value over time.

5. Predictive models and applicability to northern Canada

BHP Billiton-We are constantly tasked with preparing habitat compensation plans using models based on southern species.

BHP Billiton-The environmental monitoring programs commenced without the benefit of northern models for use.

BHP Billiton-Too often we are required to conduct programs based on southern models without knowing if these models are applicable to the north.

Canadian Natural Resources Limited-The development of habitat models is extremely lacking, both for species of low value such as forage fish and for site-specific or perhaps even river-specific methods to calibrate or validate models for all fish species in the oil sands area. On this topic there is also little understanding in the region on how to develop and measure productive capacity for rivers and lakes in order to calibrate between the two for comparative purposes of compensation, and "no net loss" assessments.

Johansen-We do not use a Habitat Sensitivity Index (HSI) but we use the area impacted of a particular type of habitat (area acting as a surrogate of productive capacity). We have found that the use of HSI and Equivalent Habitat Area can be very subjective and they have usually been developed for some other part of the country or continent and are not applicable to the particular system being evaluated.

von Finster-People look at northern streams and try and fit them into southern paradigms. Habitat Suitability Index (HSI) has been used in the past, but appears to be a poor fit. If any part of the pathway breaks down, the population is impacted. Concern is that a chinook stock adapted to the Sacramento River is fundamentally different than one adapted to the Porcupine River.

von Finster-The Arctic grayling HSI is based largely on southern stocks.

Dahl-We use the Habitat Suitability Index (HSI) times areal extent of habitat impacted. What is needed is a no net loss (NNL) procedures manual, so proponents and DFO know the ground rules. The currently available model (HAAT) used south of 60° is not applicable to streams or northern systems. We hope to get standard HSI tables with northern information. The use of HSI times areal unit is often highly subjective, difficult to test in the field. We look at species individually, but need a table of HSI for individual species.

Shamess and Majewski-The "published" HSI models produced by the USFWS and used without modification have resulted in poor outcomes. These models need to be verified or better models need to be developed for northern-Canadian conditions.

Merkowsky-Presently we are using the general HSI to determine the importance of fish habitat and supplement with site-specific data when available.

Merkowsky-Information is available in the various Habitat Suitability Indices that have been produced by the U.S. Fish and Wildlife Service but these indices are quite general.

GLLFAS and FWI-In the Great Lakes, predictive littoral habitat-fish biomass models have been developed (Randall). Similar methods could not be developed for the northern lakes because empirical data are not available. Some of the methodology used in the south by Burlington scientists may be applicable to the north in future.

GLLFAS and FWI-Habitat Suitability Indices (HSI) that were developed in the south are not generally applicable in the north. HSI must be used on the ground by experts who can calibrate the indices. We need a consensus on the habitat requirements for lake trout and charr north of 60 to standardize these models. There is a need for better validation of HSI. Minns' suitability model is seen as a simple first step.

GLLFAS and FWI-A straight habitat analysis with our model (Minns' Defensible Methods) is the first stage followed by DFO research on, for example, finding thresholds in terms of "bottlenecks," and the rate of change of habitat before it becomes catastrophic change with serious implications to fish production.

GLLFAS and FWI-Need for the greater use of models, such as those used for chemistry and water budgets. Biological information may be anecdotal, and hence DFO needs to address this deficiency and integrate data into models.

6. Databases and archiving

Rudolph and DeBruyn-The habitat programs at the area, regional and national level do not have a substantive mechanism by which to collect, archive and make available data collected for project-specific purposes which may be useful to other assessors within the region or nationally. A national Subject Matter Expert would be a start to achieve this.

Rudolph and DeBruyn-The data from these studies [pre-impact sampling and post-impact studies] should be archived in a manner which makes them more useable.

McCart-An archiving of samples should occur to permit analysis of collections in the future.

7. Impacts on fish and fish habitat

Klondike Placer Miners' Association-We also need to understand the interrelationships of industry impacts to help us with practical aspects of understanding natural systems. Understanding natural variability is therefore a key.

Miles-How long does placer mining elevate sediment in waters is an issue that is currently regulated based on an end-of-pipe measurement. This is not very relevant because the slope and channel instability is a major source of sediment loading to streams.

Miles-There is a legacy of issues from which we can gain some insight for future decisions. Indian River valley – sediment coming from ponds is but a small part of the sediment movement and deposition in the system. The Indian River was an oligotrophic stream surrounded with vegetation but its transition over tens of years has created a wide, shallow valley with numerous side "lakes" and in the short term, warmer conditions. The positive or negative consequences of the change are not known.

von Finster-Cumulative impacts have not been addressed to date. Main species of concern is chinook. This industry [placer gold] is limited to flowing waters or to fossil landscapes beside flowing waters. Where sites do flow into lakes, the effect is considered to be at the ecosystem level.

von Finster-On watershed ecology and placer mining: most of the streams that were placer mined in the past will not be comparable as ecosystems to non-placer-mined streams for an extended period.

A two-tiered monitoring system is necessary.

To define/describe "ecosystem health" in the context of "watersheds" requires consideration of the current definition of watersheds within the YPA. In the Yukon River, the "organism" used defines the "community." "Health" becomes a measurement of the condition of the ecosystem – which, in streams (in comparison to, say, deep lakes) is dynamic and has significant weather- and climate-induced ranges of diversity and abundance of various species and of overall "productivity." Therefore the condition of an affected watershed would be related to a reference or "control" ecosystem on a real-time basis.

Watershed – Technically, YPA Basins are not watersheds, but Management Units that were chosen for the administration of the YPA Dilution Model – first came the concept of the Model, and the Management definition of "Basin" followed. If a dilution model is to be used (either the 1993 YPA or some derivative thereof), then the "watersheds" should meet the requirements of the new model: concept determines definition.

"Watershed Management" or "Watershed-based Management" is an ancient concept. It is a fundamental planning tool. It is imperative that the indirect effects are also considered (the dilution model used in the YPA is effluent based), particularly those that persist after activities located upstream cease.

It is critical to consider that the current level of placer mining on streams reflects the current economies of mining – if the price of gold were to rise significantly, there would be a great deal more activity.

To measure health/condition use a surrogate. The obvious one is fish, beginning with their habitat.

The structure of a non-disrupted stream is related to the gradient, parent material, glacial history and the size and structure of the upper landscape (i.e. the "watershed"). Usually, the smaller the stream the larger the influence of the large organic debris in providing stability and in creating lateral and vertical complexity in the channel.

A non-disrupted stream is generally sinuous, has pools, riffles, glides, has a wide range of velocities and depths, and has a bed that often extends under the forest floor.

The structure of a stream disrupted by placer mining tends to be straight, to have limited complexity (usually a long and constant riffle), and – importantly – to be constantly subject to high levels of sediments (not necessarily turbidity, as it includes bed loads) from upstream.

In respect of Yukon fish, sampling with seines, gill nets and electrofishing is most effective when the water is turbid. Given the above, fish are, in my opinion, a poor surrogate for determining the condition of the ecosystems in Yukon streams, with the possible exception of slimy sculpin spawning success.

Other fish species/life stages are poor surrogates for determining the condition of streams, at least as the presence/absence of wild individuals.

To conduct a credible assessment of a mined creek in respect of a reference stream would be expensive.

Benthic organisms are probably a little better than fish as surrogates. There has been a tremendous amount of benthic sampling in the Yukon, and much of it was specific to placer mining.

Dahl-We do look at cumulative effects in a water body or stream. Sadly lacking is assessment of cumulative effects on a watershed basis. It is not known how fishing out a population will affect the overall watershed. We need a protocol for what to consider on a watershed basis.

Shamess and Majewski-It is impossible to truly address cumulative effects with this approach [the current regulatory regime]. AOS [Alberta oil sands] developers rely heavily on models to predict the long-term cumulative effects.

Shamess and Majewski-DFO identified the uncertainty and the potential significance of cumulative effects as a result of two recent AOS project applications.

Shamess and Majewski-EIAs conducted in support of AOS applications are based on a limited baseline sampling period (~2 years). Long-term predictions must be made that incorporate landscape differences, flow changes and climate change – to name a few.

Shamess and Majewski-Prairies Area HM has been pressing for a regional review of the oil sands development issue.

Gordanier and Moggy-Cumulative effects are considered as part of CEAA and there are concerns at the fish population level and lake/watershed level.

Merkowsky-Regarding cumulative effects, this aspect of habitat loss has not been addressed within Saskatchewan. I suggest using a hierarchical approach beginning at the scale of the major watersheds that have been identified by Environment Canada for the stream flow monitoring network. The information on habitat losses from authorizations and gains from compensation would be input into a GIS database. This system would then be subdivided into smaller watersheds.

Rudolph and DeBruyn-Habitats specific to high water flows or groundwater upwelling (spawning) have proven to be a concern as many mining projects involve surface water flow and/or groundwater flow alteration. Habitats supporting traditional fisheries are often a concern with mine development.

Rudolph and DeBruyn-Staff must consider the loss of habitat to the specific water body and how that will affect the existing fishery. Where the entire water body is proposed to be removed, then staff will need to look at the loss of that water body (e.g. a lake within a watershed) and determine if the loss of that lake will result in a loss of habitat for the fish species within entire watershed or if the loss of habitat will result in only the loss of direct and indirect habitat at the site only and the fish species/stock can still continue to exist within the watershed or sub-watershed.

Rudolph and DeBruyn-If a whole lake is removed from a watershed where 10 other lakes exist and the lake is replaced by a bypass stream for operational issues and the principle species of concern is brook trout which will continue to survive and migrate throughout the watershed in the remaining streams, channels and 9 lakes, then the Habitat

Policy, the *Fisheries Act* and the Habitat Conservation and Protection Guidelines (1998) are applied differently than where critical habitat is involved.

Rudolph and DeBruyn-Cumulative impacts are addressed under a CEAA review as a result of the section 35(2) trigger. In the most basic sense, if a proponent is in a remote area and is proposing to take one whole lake from the area, there is no cumulative impact. The decision to authorize one or more lakes whether cumulative or not will be based on the specific circumstances of the proposal.

Rudolph and DeBruyn-OGLA [Ontario Great Lakes Area of DFO] staff are to consider what the impact of the project is on the fisheries community before making a decision to authorize or not.

Rudolph and DeBruyn-Although not explicitly required under the DFO policies and procedures, there is an inherent decision-making process which does contemplate potential cumulative effects before reaching the decision to authorize or not. If there is a decision to authorize, CEAA is triggered and then OGLA staff will specifically require of the proponent to address cumulative impacts.

Bérubé-Mining has considerable impacts at the fish population, lake and watershed level. The vast majority of mining developments commenced operating a number of years ago and DFO was not involved in assessing the impact of these projects on fish habitat. We therefore do not have extensive experience in assessing the cumulative effects of these types of projects.

Bérubé-DFO has been assigned a number of files whose cumulative impact must be considered. We intend to assess them at the watershed level, i.e. taking a "macro" approach to the impacts involved.

Bérubé-Cumulative impact assessment on a narrower scale would require a tremendous amount of energy and would involve a great deal of uncertainty due to gaps in knowledge. Impact assessment at the watershed level will reduce the effort required to assess impacts, while taking into account the other issues present in the watersheds and maintaining a solid notion of the potential long-term impacts of mining.

Bérubé-We lack information on the impacts of severed water links, of earthworks and of the drying out of numerous watercourses in a given watershed; and the cumulative impacts of mining.

Grant and Dawe-HM staff have adopted a precautionary approach when assessing lake impacts by trying to protect the widest possible variety of fish species, including their different life stages (i.e. species that directly or indirectly support, existing or potential, commercial, recreational, and/or Aboriginal fisheries).

Bradford-The section [in my commentary sent to you] considers the task of estimating the likely health of streams across a large area that might be impacted by different types and intensities of human activities. Included is a traditional stream channel assessment – all are highly variable in natural systems often difficult to measure systematically. These measures are really only the symptoms of larger issues that are usually impacting the whole basin. Considerable attention has been focused on the use of biotic diversity to measure stream health. IBI approaches are particularly useful for water quality issues where changes to stream health may not be readily apparent from evaluations of physical habitat or catchment land-use patterns. Numerous studies have identified relationships between invertebrate abundance and diversity and placer mining. Collectively, these results suggest that stream invertebrates could be used as a monitoring tool to assess the impacts of mining, or evaluate recovery from mining. Invertebrate diversity and abundance may be useful as a long-term monitoring tool for evaluating stream health changes as a result of impacts or recovery. The primary mechanism linking stream invertebrates and placer mining is suspended and deposited sediment. Therefore, invertebrates are unlikely to be a sensitive indicator of other attributes of fish habitat that might be affected by placer mining – such as riparian structure, LWD loading, channel morphology, etc.

Bradford-With the advent of GIS capacity it is possible to compare measures of stream health with land use in the catchment. Stream health and catchment state are inexorably linked. A number of these studies have related invertebrate biodiversity and fish abundance to catchment land use. A common result of these studies is that stream biodiversity is negatively related to measures of catchment land use (both present day, and historical) and the relation is linear. That is, there are no "thresholds" for development before an impact will be observed. The corollary to this work is that stream health can be likely assessed by quantifying the human impacts on the landscape. Quantifying and monitoring land use may be a useful index of the likely status and direction of change in stream habitat condition. These measures will not be sensitive impacts unrelated to land use, such as chemical pollutants. Land-use impacts for watersheds can be evaluated with air-photo interpretation

Bradford-A stream health monitoring program should carefully consider its goals, before getting into the details of what to measure. Some attributes of stream health that might be considered are: watershed condition; riparian zone condition; channel form; channel bed; water quality and quantity; stream biota; fish.

Hartman-These comments are given in a context that pre-supposes major expansion of the industry and activities over large areas. The diamond mining industry has staked an area about half of the size of Alberta. If diamond mining is highly likely to remain confined to a small number of restricted areas, the comments about understanding ecosystem level processes may not be very relevant. However, the first placer operation in the Yukon began with impacts on one stream. The first logging in BC began with low-level impacts in isolated local areas along inlets. The comments about research needs are predicated on potential developments that are extensive and/or numerous in the Canadian north.

GLLFAS and FWI-At the Diavik mine, effluent from the operation will double the nutrient content of Lac de Gras, which is 1000 km^2 in area. Nutrient enrichment may disproportionately affect the delicate balance in simple northern ecosystems that have evolved under low nutrient loads. The value of any stimulation of biological productivity by increased nutrient inputs will be contingent on the nature and magnitude of the inputs, and on the capacity of the ecosystem to respond without imbalance.

GLLFAS and FWI-Diamond mines have established unique circumstances in northern lakes. For example, with respect to the discharges of nutrient-enriched waters that may attract fish.

GLLFAS and FWI-It is predicted that the central barrens will get warmer with climate change. Climate change could result in additional stress with adverse consequences. Cumulative effects are the most difficult to address, especially on a large watershed basis. We really have no idea about cumulative effects in the north.

8. Funding and partnerships

Pacholek-The intent of the Northern Ecosystem Initiative is not only to be a funding source. The Resource Use Table (Paula Pacholek, chair) is currently focusing Phase 2 activities of the Northern Ecosystem Initiative on determining thresholds for cumulative effects on the environment due to development. Very broad environmental issues exist north of 60, encompassing topics such as contaminated sites, climate change, and monitoring of impacts of resource use. The Phase 2 Studies are focused on biological mapping, and tools for advancing cumulative effects assessment (models, etc.).

Pacholek-A meeting was held in Calgary, December 2003. Aboriginal communities voiced a desire to better manage their own information.

Pacholek-Thresholds work – it is the key issue for us at present. Cumulative effects researchers have said that one should not carry out project-by-project assessments, and that an understanding of thresholds is required to add to decision-making processes for different species. Three groups have been organized which are for aquatic, terrestrial, and social science concerns.

Pacholek-Social science needs to develop the indicators or thresholds, that is, the point of no return, using dose-response curves. In our view, the social science aspect is key to building community relations in the north. We want the researchers to convince us about the importance of thresholds so that we may take these arguments to the communities; we want to have a solid proposal before engaging too many people. In the north, livelihoods are based on, for example, fish and caribou, so we cannot wait until populations of these animals decline and "crash." What drives populations? Is it the human interaction, or natural population variation?

Pacholek-Criteria are being developed for the determination of environmental thresholds for cumulative effects. The development of threshold setting has the highest priority for us. The models are only as good as the information put into them. We have some baseline work from the Northwest Territories, and with the data from Alberta, better management models should result.

Isabelle-Collaborative Research and Development (CRD) grants exist wherein university applicants lever NSERC money if there are industry partners. Other programs include Strategic Project grants. There are also Northern Research Chairs associated with certain universities.

Dick-Current Arctic research includes work on: food webs, stable isotopes, food, parasites, disease, trophic patterns, in large rivers, modeling 3-D river systems regarding fish habitat, sonar/acoustic technology employed and GIS mapping, status and behavior of sturgeon in lakes, Chitty Lake habitat use studies, and bio-energetics. Trophic feeding levels, are being studied. Community component – incorporate traditional ecological knowledge (TEK).

Hartman-The needs for research funding and staffing must be put up alongside of the revenues and/or income from the industry. Strong, long-term, ecosystem-based process research should be funded to be carried out in this fragile, vulnerable and changing part of Canada, subjected as it is to expanding and cumulative impacts. This type of work must be led by government as was done very successfully for years in the Carnation Creek watershed project.

I do not believe that DFO is currently meeting its obligations in research and management in spite of the efforts of the good people who are out on the ground doing their best. There are needs for more than catchy "administrative pathway systems" in northern management. They are sound science, development of field experience, staff continuity and overall commitment to the resource.

9. Collaborative studies

BHP Billiton-Research is not the mandate of industry. Projects should be conducted jointly with government. Regulators should be more involved in collaborative approaches

BHP Billiton-There is so much monitoring data being generated, but the data are analyzed to look at effects but not at the ecology of the systems. There are still amazing possibilities for joint research.

BHP Billiton-We, in industry, are fully willing, keen in fact, to cooperate, and would like to see the information we have generated used in making recommendations for developing adaptive management strategies that are relevant to our operations.

BHP Billiton-Studies need to be of benefit to companies for industrial collaboration to occur.

BHP Billiton-The industry is not organized into any group that would assist in the design and planning of research. If there were such a cooperative group, we could meet once or twice a year and, it could be very useful.

De Beers-Research in the field should be focused on compensation, and De Beers is willing to undertake cooperative research in this regard.

Diavik-The collaborative approach to provision of information is workable. Leaving it as an industry-based initiative will not be optimal. Diavik is already undertaking a collaborative research project with University of Alberta (Bill Tonn) regarding the impacts of blasting.

Diavik-Environmental Advisory Board of Diavik is community based.

Klondike Placer Miners' Association-We favor a cooperative approach to research projects.

Canadian Natural Resources Limited-The research and information needs are driven by DFO requirements.

Canadian Natural Resources Limited-This collaboration [with DFO/universities/other industries] is an essential part of research. It must include all sources to be representative, which will enhance credibility. It should also include traditional knowledge where appropriate.

Suncor-Collaborative research is the most effective method of achieving research results that meets the needs of a variety of interests.

Albian-The breakdown of organics is not fully understood.

Albian-Placer miners such as those at Atlin, BC, are very small operators with small operating margins. As a result, they cannot begin to do 1% of what we have done in research.

Albian-CONRAD [Canadian Oil Sands Network for Research and Development] is a recognized successful model. The concerns of the Aboriginal community [are brought to the table through multistakeholder committees].

Albian-We need to work together.

Golder-More collaboration among researchers from the regulatory agencies, universities, industry and other players can only be beneficial to the maintenance of the aquatic resource, and is strongly encouraged.

Golder-There is opportunity (and benefit to be gained) by investing cooperatively in joint ventures: different measures of dealing with habitat or fish communities; different compensation measures; and compensation which is "managed" or adapted.

Johansen-Collaboration has proven useful to DFO.

Shamess and Majewski-The oil sands companies in co-operation with academic institutions are undertaking research. CEMA and CONRAD are sponsoring research on reclamation and wetland recovery.

Shamess and Majewski-Collaboration is advantageous to all.

Merkowsky-Regarding collaborative studies/monitoring, this has not been readily pursued to any great extent in Saskatchewan.

Rudolph and DeBruyn-Regarding the value of collaboration, yes, a number of science for habitat workshops have been held with other agencies and with industry.

Rudolph and DeBruyn-Senior DFO Management sees the Canadian Electricity Association MOU as the way DFO should be doing business in the future.

Grant and Dawe-Collaboration with Industry on monitoring/research ventures would be mutually profitable. The Department must encourage a more cooperative and mutually-beneficial relationship between regulator and proponent. One recent example of mutual collaboration was the NL Region's Fish Habitat Compensation Information Sessions. MEHM [Marine Environment and Habitat Management of DFO] also promotes value-added research being undertaken in conjunction with compensation works.

Bérubé-Regarding collaborative studies, we have no experience in that area. In the Quebec Region, a DFO-Industry partnership for research would certainly be desirable. However, as explained in the response to question 4, the Quebec Region performs no freshwater research; consequently, such a partnership would be difficult to establish. The Quebec Region of DFO prefers to have industry do its own impact monitoring pursuant to the Region's recommendations.

Dick-People question DFO's Index of Biotic Integrity for the Arctic, but we have little specific information. Regarding cooperative research with industry, it is important to focus "the problem" from the outset. Valid empirical information is needed to test models. I believe now that a Network of Centres of Excellence [linked with industry] is really needed that deals with people and natural resources and the environment; the umbrella for all this is building capacity in the north for decision making.

GLLFAS and FWI-Any ecosystem-based approach requires substantial co-operation among federal departments.

10. Fish habitat compensation and restoration

BHP Billiton-There will be more diversion channels required in relation to diamond mining and for fish habitat compensation.

BHP Billiton-Even though we design compensation plans, it is DFO that decides on what is appropriate for compensation.

BHP Billiton-The Panda Diversion Channel is the only existing compensation work we have.

De Beers-A spawning habitat was created. Research is needed regarding habitat compensation techniques.

De Beers-Criteria and methods are required to assess whether the spawning structure has been a success. Opportunities exist to study this compensation activity – a coordinated approach will be necessary.

De Beers-Regarding compensation options, the improved access for fish to additional habitat is one of the better options. Increasing the depth of lakes is also a consideration.

Diavik-The plans of Diavik regarding "no net loss" of fish habitat have been quantified through "habitat units." Uncertainty in compensation is dealt with through the provision of more "habitat units," and monitoring will reveal whether they were used.

Diavik-With respect to compensation for habitat lost, there are options to improve access to fish-less lakes and for Aboriginal fishing, and also to increase the depth of shallow lakes.

Diavik-Fertilization of lakes is ruled out as option from a scientific perspective.

Klondike Placer Miners' Association-Priority research will likely be identified by the Implementation Steering Committee to support the new regulatory regime and to put measures in place to demonstrate no net loss (NNL), and possibly a net gain (NG) of fish habitat.

Klondike Placer Miners' Association-We need to evaluate the techniques that will ensure productive streams after restoration.

Klondike Placer Miners' Association-As the new placer mining management regime is developed, independent research is required to monitor the effectiveness and achieve NNL. How change is evaluated is very important. For example, to assess the effectiveness of compensation -we need to know what the end results are. Are they healthy, productive streams? What has changed?

Klondike Placer Miners' Association-We need short term assessments to give comfort, but cannot ignore the 5 to 10-year term and the 20+ year term.

Klondike Placer Miners' Association-There is a need for holistic studies on stream health and restoration.

Klondike Placer Miners' Association-We need to do short-term research to feed back into an "adaptive management tool." The current research being conducted (primarily by Yukon government biologists to understand the biological and physical effectiveness of our restoration practices) will be useful.

Canadian Natural Resources Limited-[With respect to assessment of success/failure of compensation/restoration], this is unknown at this time and is not being clearly answered, however, it is the opinion of Canadian Natural that the standards for this must be set by the regulator, DFO, and can be transferred to the proponent of the project once the methodology is accepted and is reasonable for the compensation/restoration being assessed.

Suncor-Our experience indicates that DFO alone decides what compensation is appropriate for a given HADD. However, exactly what is "appropriate" compensation is not clear to industry. The applicant generally recommends its own measures of success.

Albian-"Tools" are required, for example, concerning the rebuilding of a stream.

Albian-We are doing a lot of riparian research. Wetland (water-covered land) reconstruction is easy but not a lot is known about the holistic approach to stream reconstruction. Reclaiming back to the original muskeg is difficult for several reasons. With little moisture-holding capacity it would be difficult to reclaim this land.

Albian-Reclamation takes a significant length of time to realize. Mining activity will continue on our lease for 30 to 40 years. We need to have long-term plans in place to help minimize reclamation costs.

Albian-Another priority research area is that concerning end pit lakes. The earlier in the process that one can decide upon a final elevation the better as it will allow one to plan for an appropriate littoral zone so when the end pit fills, a 2-m deep zone with soil exists along the shore to allow aquatic vegetation to establish itself. [We end up with a lake when] a pit fills. If done correctly this could be considered to be compensation for lost habitat. During the development of the mine, 80% of muskeg is going to be converted into upland terrain.

Albian-A lot of work is being done on the reclamation of soil and vegetation, wetlands, and aquatic habitats – 40 committees and subcommittees are active in these areas.

Albian-Rehabilitation measures will not satisfy everyone.

Albian-Our riparian work focuses on the plants.

Albian-We need to focus restoration where it can do the most good, such as where there is greater productivity, or in places that were productive and were destroyed a long time ago.

Golder-When working in virtually-pristine areas the replacement of previously-damaged habitats is not an option.

Golder-In the oil sands region, abundant opportunities exist for significant net gains in fish habitat in the watercourses and lakes (end pit lakes) that will exist on the reclamation landscapes. These opportunities tend to be discounted by DFO. In the bigger picture, this is possibly the biggest opportunity for creating net gains in productive fish habitat, as at this stage of development each project will have already achieved the "no net loss" principle.

Golder-DFO should continue its involvement in, and possibly substantially increase its role in research projects designed to provide guidance in the development of productive, sustainable aquatic environments on the reclaimed landscapes.

Golder-The decision on the appropriateness of compensation/restoration actions is simply that of the DFO practitioner involved.

Golder-Project proponents typically focus more energy on this activity [obtaining input from NGOs] than DFO does.

Golder-The measures to be employed to determine success/failure are typically specified prior to the issuance of a section 35 (2) authorization by DFO, which is appropriate. Typically, the proponent is required to continue the development of such options until the DFO practitioner is satisfied. In reference to all three components of the question (appropriateness, success/failure and measures), virtually every section 35 (2) authorization contains the phrase "to DFO's satisfaction," which rightly or wrongly may be interpreted as "to the satisfaction of the DFO practitioner," such that it is quite clear who the decision maker is in terms of whether these objectives have been met.

Miles-It is difficult to create ecologically-functioning streams, and a better option is to seek ways to increase access for fish to other habitat that is not used by them.

Miles-With respect to [aquatic] vegetation in northern regions the time frame for growth is prolonged, and there is the danger of hypoxic conditions through the use of fertilizers used to stimulate growth.

Miles-Instant-functioning ecosystems are difficult to create but do not rule out the short-term benefits that can be obtained through restoration measures.

Miles-Consider that mining plans should incorporate bioengineering of sites. Assessments of the morphology of channels are required. Although benthic community integrity is affected by placer mining, it is also necessary to address the issue of terrestrial food production and streamside stability (riparian zone). There is a need for the rates of recovery of disturbed watercourses to be assessed over time.

Miles-Quantification of short-term (10-20 years) impacts and changes is also required. Restoration is very costly, and the cumulative impacts of mining are unknown.

Johansen-We require a detailed habitat inventory of the proposed area of impact. In addition we will ask for data on fish species, numbers and utilization of the various habitats (area acting as a surrogate of productive capacity), with a multiplication factor to deal with uncertainty (compensation ratio). Or if a limiting habitat factor in the system can be identified we will focus the compensation efforts towards that limiting factor.

Johansen-With respect to the current knowledge, I believe that it is not reasonable to suggest that research could truly allow DFO to identify what a successful compensation plan for whole lake destruction would be. The magnitude and the complexity of such a compensation plan are beyond the scope of the current and foreseeable understanding, and this is the same for any complex system that has structure and function.

Johansen-Compensation ratios are developed for all proposals where an authorization is given. Compensation proposals that have a higher risk of failure will have much higher ratios.

Johansen-We have had instances where compensation for habitat components has been somewhat successful. Considering the Kemess South Mine, with the pristine nature of the surrounding environment it was difficult to devise compensation measures that did not in themselves pose additional environmental problems – another key challenge in remote locations. In northern BC, at the Kemess South mine development which we authorized in 1996, the compensation plan for the TIA included a significant research component on bull trout life history which has been very valuable and is still ongoing. The proponent has made facilities available to graduate students, allowing them to conduct research on the site. All of this information has added greatly to the understanding of bull trout life history and habitat requirements and preferences and will assist DFO in future developments that have the potential to impact charr species.

Johansen-Uncertainty is handled in several ways. Compensation ratios, performance criteria for the compensatory habitat, approved contingency plans if performance criteria are not met within the specified time frame and financial securities are always required in case of a default by the proponent.

Johansen-Each lake is different and would require years of study to get a basic understanding of how it all works.

Johansen-While one might be able to identify the components being impacted and attempt to compensate for them, getting everything just right so the components function as hoped is a huge challenge, if not impossible.

Johansen-Our monitoring reports have suggested, through our qualitative assessment, that we have been very successful in meeting NNL.

Johansen-For projects where components of fish habitat are being impacted, and if we are compensating properly, there should be no residual impacts to be considered as part of cumulative impacts assessment.

Johansen-Consideration of compensation for whole ecosystems is certainly beyond the scope of any assessment process or habitat biologist's expertise.

Johansen-We may require specific contingency plans that would apply if the performance criteria of the compensation are not met, or there is a high risk of failure.

von Finster-Where a stream is laterally unstable due to past practices, there is no hope of creating a fish habitat compensation ratio of 2:1.

von Finster-There has not been any real restoration in placer mining.

Dahl-There has been community opposition to the enhancement of otherwise-pristine habitat.

Dahl-DFO Science has used habitat compensation ratios of at least 2:1 to achieve NNL. This has been recently reviewed and higher ratios of 3:1 or 5:1 have been recommended. Practitioners need the time to do follow-up evaluations of compensation effectiveness. 2:1 is seen as one-third risk; one-third interim loss and one-third net gain. Where uncertainty is high, we target more areal compensation. A Habitat Unit approach is used, but we need monitoring and success criteria. It could be generalized as a decision-making tree.

Dahl-Nothing in the way of lake habitat compensation is in place for diamond mining.

Dahl-We have received some scientific advice, but there have been no actual studies on quantifying effectiveness of compensation measures. There is research funded by Ekati on the Panda Diversion Channel. On Long Lake the trend series analyses are all based on water chemistry, which DFO is not directly involved in.

Dahl-We do not always know in what way the habitat is important; we do not completely understand how it is used; so we do not have lake compensation examples to learn from to compensate for its loss.

Shamess and Majewski-2:1 ratio replacement was selected arbitrarily for the AOS projects based on the assumption that the habitat in the affected regions was not considered critical, and there is potential for limited on-site fish habitat compensation. We have no record to determine if 2:1 is adequate.

Shamess and Majewski-In the AOS region, end pit lakes are not considered compensation. There are no completed oil sands projects yet, so compensation success cannot yet be evaluated.

Shamess and Majewski-The fish habitat losses in existing oil sands mines have not been extensive. Existing projects have sometimes incorporated off-site compensation.

Shamess and Majewski-Regarding compensation the DFO regional office has contracted work to several hydrologists (hydrological modeler, stream hydrologists) and to a fish biologist to assist in interpreting information provided in support of AOS applications. The proponents will be required to monitor fish populations in compensation habitat. The results of the monitoring will determine the effectiveness of the compensation.

Gordanier and Moggy-Regarding initiatives underway to examine fish habitat compensation and restoration activities, there are none that we are aware of.

Merkowsky-A habitat compensation agreement between Saskatchewan Environment, DFO and Claude Resources for the East Lake TMF was signed in 1992. There was no financial guarantee incorporated into the Habitat Compensation Agreement. Claude Resources began construction of a reef for lake trout in a lake (Porky Lake) near the mine site.

Merkowsky-During the review process, it was difficult finding suitable compensation for the destruction of Triangle Lake. It was decided to defer compensation for the destruction of Triangle Lake, but that a financial guarantee would be put in place as part of the agreement. Factors considered in calculating the cost estimate included the costs for constructing the reef and for a monitoring program to determine the utilization of the reef for spawning.

Merkowsky-Primary focus in Saskatchewan is game fish populations. Compensation for the HADD of forage fish habitat has generally not been required.

Merkowsky-Generally account for uncertainty by doubling or tripling the size of the compensation area.

Rudolph and DeBruyn-For instance, in the example above, where one lake out of 10 brook trout lakes is taken out of a watershed, there is arguably a 10% reduction in the fisheries resource for the watershed which may be acceptable within the fisheries resource management objectives for the area (Ontario Ministry of Natural Resources) with some suitable offsetting compensation which achieves the Policy objective of a net gain.

Rudolph and DeBruyn-I expect the question really is how do DFO staff make a decision when it is uncertain if the compensation will offset the potential loss of the fisheries resource. DFO staff will request as much information from the proponent as required before making a decision.

Rudolph and DeBruyn-As mining is becoming increasingly more feasible in northern Ontario and relatively little information is available on proven compensation methods, there is always a level of uncertainty involved in mining project reviews. Much of the uncertainty that staff have in relation to this question is that DFO and most resource agencies do not have a good tool by which to define what the existing fishery is and then a good tool to measure how much of an impact will be felt in that fishery if a part is removed. And then further, we have no good tools to measure the effectiveness of the compensation to offset the loss of something for which we had no definitive number for in the first place. This circumstance gets more uncertain when a compensation or mitigation approach is proposed which is new or conceptual and unproven.

Rudolph and DeBruyn-Typically, OGLA staff continue to rely on the simplest approach to request information and compensation approaches on an area lost to area replaced basis according to the Compensation Directive and hierarchy of preferences. These decisions are strongly influenced by the individual's ability to take a common-sense approach, which attempts to make the decision in respect of what the impacts to the fish will be rather than the perception of others.

Rudolph and DeBruyn-Great Lakes Laboratory for Fisheries and Aquatic Sciences (GLLFAS) has undertaken lake habitat manipulation research.

Bérubé-We lack information on the restoration capacity of sites; and we have no experience in restoring mining sites. In Quebec, however, the provincial Department of Natural Resources has collaborated in the restoration of several sites.

Bérubé-DFO is reviewing existing mining projects for the purposes of the MMER with regard to their impact on fish habitat and compensation. DFO has no site restoration initiatives in this Region.

Grant and Dawe-Identifying/determining fish habitat compensation options for habitat loss in lacustrine (lake/pond) environments continues to be challenging. Similar information for lacustrine systems (e.g. whole lake destruction) is limited, particularly in relation to northern environments.

Grant and Dawe-The NL Region follows a precautionary approach to fish habitat compensation as a means to reduce the level of uncertainty associated with the success of compensation options for whole or partial lake destruction. Fish habitat compensation for mining projects has included increasing the productive capacity of fish-less lakes via the transfer of fish from impacted ponds. Compensation for partial lake loss has included improving and/or increasing littoral areas and/or adjacent riverine areas that are utilized by fish.

Grant and Dawe-The Region utilizes two primary data collection requirements to further reduce uncertainty associated with a compensation option. The first is a requirement for the proponent to conduct compensation baseline studies related to specific issues and/or data gaps associated with a particular compensation option. The second requirement is for an extended compensation monitoring program to determine whether conditions of the compensation program have been met and to determine how well the new habitat is functioning as designed. Its duration is dependent on both the complexity of works to be undertaken and the species life stage requirements.

Grant and Dawe-With respect to lacustrine fish transfer programs associated with whole lake destruction, the monitoring period is usually greater than ten years. If monitoring reports indicate that a compensation program is not functioning as designed, this Region [Newfoundland] has required proponents to carry out modifications to the compensation program.

Grant and Dawe-At the Luce Pit Continuation of the Carol Mining Project, the compensation plan consists of increasing the productive capacity of White Lake (a fish-less lake) through the relocation of fish from Hakim Lake and Hakim Brook to White Lake and the creation of spawning and rearing habitat via construction of a channel at the outlet of White Lake. The plan also provides for the creation of salmonid spawning and rearing habitat at Tinto Brook, along with modifications of the Tinto Brook culvert to provide fish passage to Wabush Lake.

Grant and Dawe-At the Voisey's Bay Mine/Mill Project, to compensate for the loss of productive lacustrine and riverine fish habitat, VBNC will increase the productive capacity of Pond 61, (a fish-less lake), through the relocation of fish from Headwater Pond and the establishment of a naturally-sustaining population in Pond 61. In addition, VBNC will establish a habitat restoration program where VBNC, in consultation with the Innu Nation and the Labrador Inuit Association (LIA), will identify suitable candidate site(s) for habitat restoration within Labrador.

Grant and Dawe-In the Carol Project Tailings Management Plan, to compensate for the loss of productive fish habitat associated with the construction and operation of the tailings confinement dyke, IOC will create 43 ha of lacustrine habitat equivalent units along the outside face of the dyke. In addition, the company will improve the productive capacity by a minimum of 633 ha of habitat equivalent units within Wabush Lake through the confinement of tailings, consolidation of discharges, and routing of all tailings to the confinement area.

Grant and Dawe-The pros and cons of working in northern environments are listed below:

Pros: The Department can gain insight into potential compensation/restoration options by consulting with the Aboriginal community, in particular as it relates to traditional ecological knowledge (TEK).

Cons: Logistical problems (e.g. gaining site access, short field season, etc.). Climate/geomorphology of the environment (tundra, rocky coastlines, etc.). Enhanced public scrutiny/Aboriginal issues/limited opportunities for enhancement/restoration.

Grant and Dawe-To date, there have been no case studies concluded on compensation initiatives within Labrador, however, projects have or will have long-term monitoring programs and as such, the Department will be able to assess the effectiveness of these compensation options as they progress.

Grant and Dawe-In the NL Region, HM has always encouraged and promoted partnering with the Department's science community with respect to value-added research over and above existing compensation programs. HM has partnered/participated with the Environmental Sciences Section in research programs within insular Newfoundland aimed at evaluating the production characteristics of created/enhanced compensation channels. HM has initiated a multi-year study to identify and/or evaluate possible enhancement/restoration sites throughout the province for consideration as suitable compensation options.

Hartman-The comments that follow will apply to situations where restoration programs are being carried out because of concern about specific impacts on one or more species of fish.

The process in which government agrees to a development, recognizes that habitat will be lost, requires compensation work, and then gets involved in designing such works is filled with risk. In this scenario, a developer can propose something without full and sound information or understanding; government (without full competence to understand the situation either) gets involved and agrees to a plan. When or if the plan fails, the developer is essentially off the hook because the regulating agency was involved: "due diligence."

My own view is that if government wishes to see a development proceed, but with compensation, it should agree to the project, set targets for damage control and compensation, and require that the developer gets full and proper advice to accomplish the project with end results prescribed. If the developer fails to do this and fails to get sound technical advice, the responsibility and consequences are with them.

The question of who decides what is appropriate may be a matter of operational policy. The critical issue is how it is decided what is appropriate. In many of the projects that I, or Mike Miles and I, have examined, the measures required were usually determined on the basis of judgment, not science. Projects were initiated to improve fish numbers without a sound determination of what was limiting them.

Hartman-It may not be critical who assesses success or failure. However, it is critical how success or failure is established, and over what time line the evaluation is made. Time lines should be established on an ecological basis rather than on some administrative criterion. The methodology of evaluation is critical. It may appear to be obvious, but in measuring success, the evaluation must assess the difference between what was obtained after a restoration project and what would have been there without it. Whatever a project is intended to do should be set out in a clear statement of objectives. Failure should be reported just as clearly as success.

Hartman-The measures of success should be based upon the problem being solved. In restoration work (fish-oriented) success should be measured by the increment of population increase over what would have been there anyway. If works are carried out in an area where there are several desirable species, evaluation must consider all species and life stages. I think that if compensation or restoration projects are carried out, it is essential to assess enough elements in the system to pick up such differences as growth changes, fecundity changes, population number changes (in various life stages), and indications of interaction effects among species.

Hartman-Key is evaluating long enough; having people who know how to evaluate and report objectively; funding for evaluation and maintenance; and teams of different specialists in the design, build and evaluate stages. Knowing enough about the ecosystem to be able to choose the appropriate evaluation criteria is important.

McCart-We do not know much about producing stream habitat for grayling, and less about restoring lake habitat in the north (rarely are diamond mines developed that do not require lakes to be drained or filled with tailings). A series of experiments could be done to assess fertilization effects on dissolved oxygen in lakes over winter.

GLLFAS and FWI-Compensation has typically involved only physical habitat modification. There needs to be more assessment of the ability of habitat to augment fish populations by improving its carrying capacity. We need to know to what extent fish populations can be increased by habitat manipulation. Researchers in the north are dependent on industry's infrastructure.

GLLFAS and FWI-Fish habitat compensation is often evaluated on a local basis, and not usually at the watershed level.

GLLFAS and FWI-DFO Science has argued for a quantification process for compensation because application of the "no net loss" policy requires it. The greatest resistance to implementation of a habitat quantification process to ensure no net loss has come from DFO habitat managers.

GLLFAS and FWI-Regarding diamond mining development, it is necessary to investigate what will result in successful compensation.

GLLFAS and FWI-A better geographic understanding of genetic uniqueness will alter one's perspective. The barrens' waters are highly interconnected, but phenotypic adaptation may also be operating with genotypic changes. In the Lac de Gras area, 10% of the lakes are fish-less, but these lakes could provide food and space for fish.

Compensation efforts should be directed at improving access for fish to such currently fish-less lakes.

11. Temporal and spatial considerations regarding decision making and monitoring

BHP Billiton-There has been staking of huge tracts of land throughout Canada; this is the typical nature of exploration for minerals. It is extremely speculative and large areas must be evaluated and ultimately very small areas are focused upon. Concerns about huge industry growth are unfounded for diamond mining.

There is a need to identify what thresholds are acceptable regarding the loss of lakes. The issue of watershed-level effects relates to the size of lakes and their number.

De Beers-Perhaps DFO should consider a risk-based Environmental Assessment approach to the elimination of an individual lake, and relate it to the magnitude and duration of the impact of mining activities.

De Beers-Perhaps a worst-case scenario should be assessed.

De Beers-An assessment agreement should focus on "thresholds," issues of significance, and acceptability, regarding environmental impact. Such an approach will incorporate that which is critical habitat.

Suncor-The Cumulative Environmental Management Association (CEMA – of which DFO is a member) is currently looking at environmental thresholds associated with development in our region.

Albian-Mines produce very small "footprints."

Albian-First level of reclamation that we consider is strictly physical.

Johansen-How many lakes can be destroyed in an area or a region before one considers it an unacceptable cumulative effect? This is a highly technical and difficult question to be answered in the context of DFO policy or a CEAA assessment. The answer to this question lies in the significant political and social issues that surround the technical considerations.

12. Monitoring, assessment and evaluation

BHP Billiton-A missing link in a lot of data collection is the analysis.

BHP Billiton-Government agencies should be prepared to take the data to another level, and put it against the hypotheses and conclusions drawn.

De Beers- Benefits from research and monitoring will be new knowledge.

Canadian Natural Resources Limited-Fish species distribution determinations are currently done based on professional opinion, with field data used only as a starting point, as the absence of data on a species, regardless of effort of monitoring does not exclude the potential for its presence. As a result, this can require multiple years of sampling as there is no accepted methodology to validate this.

Miles- What determines recovery, and what bioengineering is required, should be addressed.

Johansen-Detailed monitoring reports or specific research requirements that are part of an authorization have proven to be valuable for understanding impacts and the appropriate types of compensation. Many types of research involve experiments and this is an important part of gaining knowledge; certain experiments bring a level of risk with them that warrant careful consideration if the risk may be too great despite the desire for knowledge. For large or massive impacts to complex systems the risk of habitat loss is greater and the consequence of failure is large and the likelihood of failure is great. It is not appropriate to use compensation as an "experiment" in these circumstances.

Johansen-Quigley and Harper (DFO) have evaluated the success of the NNL components of the Habitat Policy based on case studies across the country. Their review has been valuable in identifying the success of the program in meeting NNL. Because of the size of the projects and the files associated with the reviews handled out of this office, they were not included in their report.

Johansen-All of our authorizations have a requirement for monitoring for compliance and effectiveness (against performance standards such as utilization and growth/success). The criteria for success are usually developed in collaboration with the proponent as is much of the rest of the authorization.

Johansen-In my opinion, a significant component of research is well-structured observation and reporting, and a well-designed monitoring program incorporates these. The reports that we typically get from our monitoring requirements allow us to make decisions on the current project as well as use that knowledge for future projects despite the fact that it is not part of a peer-reviewed publication.

Johansen-Regular monitoring and reporting is also always required to determine compliance and success.

Dahl-In terms of fish sampling, the studies are on adults, meanwhile the juveniles could be compromised by food shortages. Aquatic Effects Monitoring is chemical focused.

Shamess and Majewski-How can we design monitoring programs that will detect changes in the fish populations/behavior in the Athabasca River as a result of development? Are there surrogate predictors that are measurable that can be included in monitoring programs?

Shamess and Majewski-Monitoring is the primary tool to increase certainty.

Merkowsky-As part of monitoring programs for a number of fish habitat compensation projects at the uranium mines, reference sites are also being monitored. The gathering of information from the reference sites has thus provided habitat utilization information for some native fish species (lake trout, northern pike, and lake whitefish) in Saskatchewan. There is also a lot of information that has been gathered from various Environmental Impact Statements that should be documented in a GIS database.

Merkowsky-The operations of most of the uranium mines in northern Saskatchewan have had impacts on fish habitat that have required habitat compensation agreements. Monitoring programs have been conducted to determine the effectiveness of the habitat compensation. Final evaluations are still pending.

Rudolph and DeBruyn-Proponents collect baseline data for their project impact statements. Often these data sets are one-off items which do not account for natural and inter-annual variability and often are collected in a manner which does not represent seasonality.

Rudolph and DeBruyn-The objectives and the manner in which monitoring and research are conducted must be standardized to a certain level to be of much utility beyond the project-specific application. Science and habitat staff will need to develop approaches where pre-impact sampling methods are standardized as well as for post impact studies.

Rudolph and DeBruyn-OGLA Program Services has conducted a QA/QC program on monitoring and compliance.

Grant and Dawe-HM staff are continuously trying to improve their knowledge on regional fish habitat utilization through various aspects of project monitoring as well as collaborative research with Science.

Grant and Dawe-With respect to monitoring activities, all proponents within the NL Region are required to conduct their own fish habitat compensation and environmental effects monitoring (EEM) programs as conditions of their *Fisheries Act* authorizations.

Quigley and Harper-The comments provided herein are from workshops that were convened at the regional and national level 2003-2004.

Between 1986 and 2002, only 10 studies were conducted or commissioned by DFO that evaluated the performance of fish habitat compensation projects in achieving no net loss (NNL) of the productive capacity of fish habitat.

There has been little quantitative evaluation of habitat compensation, and there is a need for quantitative scientific methodologies to assess the achievement of no net loss through habitat compensation.

In most cases, assessments of HADDs and/or compensation habitats typically included areal measurements of the HADDs and compensation (i.e. no surrogates to productive capacity were sampled).

7% impacted "critical habitat," 64% impacted "important" habitat, and 29% impacted "marginal habitat."

Pre-impact assessments were conducted for 73% of the authorizations

From these files NNL was achieved in 10% of cases, in 4% NNL was not achieved, and for the remaining 86% the results are not known.

The primary reason for our inability to determine whether NNL was achieved was due to poor record keeping, a low proponent compliance rate with monitoring requirements, the qualitative nature of the monitoring, and the failure of DFO/proponent to establish a proper baseline in pre-impact monitoring prior to the development.

Only a small percentage of the total number of compensation projects in Canada have been evaluated.

The lack of independent, quantitative studies constrains DFO's ability to adaptively manage its habitat conservation program.

We need to conduct more studies to improve our knowledge of compensation science; employ scientifically-based, quantitative methodologies.

Field audits of compensation projects across Canada were evaluated from 52 authorizations between 1994 and 1997.

Compensation was based on specifications in the authorization and not on final fish production.

Compliance was low; on average, HADDs were 389% larger than authorized.

Assessment of 16 authorizations was made between 1994 and 1997.

In 12% of situations examined there was a net gain in the productivity of the habitat when the average compensation ratio ranged between 4 and 8:1, no net loss in 25% of cases (1:1 ratio), and a net loss in the remaining 63% of cases (0.74:1 ratio).

There is a need to select an array of biological indices in order to assess the productive capacity of fish habitat.

Most of the proponents have implemented in-kind compensation (rather than like-for-unlike). This practice has been lauded due to its propensity to maintain biodiversity.

Invertebrates and periphyton are rarely assessed in evaluations of compensatory projects.

A multi-metric approach provides a more complete picture of habitat productivity.

In many cases, selecting one surrogate of habitat productivity, rather than an array of ecological indicators at different trophic levels, would have led to erroneous conclusions.

Projects that successfully achieved a net gain in habitat productivity were characterized by actual ratios of approximately 5:1.

The monitoring requirements for habitat compensation in Canada are inadequate to determine long-term (>50 years) and cumulative ecosystem effects.

Temporal losses of habitat productivity are inevitable when compensation habitats are developed after the HADD occurs. Furthermore, temporal losses are exacerbated due to the time lag until compensatory habitats become functional.

In general, compensation sites were selected opportunistically rather than based on ecological bottlenecks and potential for success. The gross disparity in physical area of compensated versus impacted habitats was an over-riding factor for many projects.

The ability to replicate ecosystem function is limited and both improvements in compensation science and institutional approaches are necessary.

Limited success in achieving NNL does not erode or invalidate the value of this goal of the Habitat Policy. Some habitats are not possible to compensate for.

Failure to acknowledge the limitations of compensatory science raises the disturbing proposition that Canada's efforts to conserve fish habitat will not be achieving the goal of NNL.

It was deduced that habitat compensation ratios should be in the order of 5:1 to achieve a net gain. To achieve no net loss 2 or 3:1 is required. The functional linkages within and among habitats need to be addressed.

Science-based and simple methods are required to quantify net change in habitat productivity; assessments should incorporate appropriate time scales.

In terms of habitat area, it would appear on paper that Canada should be achieving a net gain of habitat productivity. However, upon inspection, the actual areas of compensation habitats are much less than required and actual HADD areas are much larger.

Non compliance with HADD and compensation areas contributed to substantial losses of habitat.

Poorly-designed compensatory works also caused habitat fragmentation. Poorly-defined requirements gave rise to situations where proponents were entirely compliant (e.g. the channel was physically stable), yet functional success of the compensation habitat was doubtful.

Although compensation ratios are intended to increase proceeding through the hierarchy of preferences (like-for-like, like-for-unlike, increase like productivity), this trend was not clear in the projects audited.

Habitat compensation, as currently implemented in Canada, is at best slowing the rate of habitat loss.

Improvements in monitoring, enforcement and compensation ratios are necessary.

Compensatory habitat should be constructed prior to or concurrent with HADD occurrence.

A simple, science-based approach is required to assess the effectiveness of compensation habitat. That is, to quantify the net change in habitat productive capacity, monitoring programs should employ a multi-metric approach.

Bradford-There is a need to evaluate the potential productive capacity of (largely) unimpacted small streams. The potential of stream habitat to produce fish will depend on the valley form and the combined influences of water, sediment and vegetation. In this section stream gradient is proposed as a simple measure of the productive capacity of segments of small streams. Recent research suggests the geomorphologic processes that create good habitat (pools, cover, woody debris; Bradford et al. 2001) are partially driven by stream gradient. Thus stream gradient appears to be a useful map-based measure for predicting the productive capacity of small streams. The situation is less certain for grayling. Data in Hughes and Reynolds (1994) show that adult grayling abundance decreases in headwater areas, mainly because pools become less frequent in higher gradient areas. Thus it seems reasonable to use gradient in a similar way for grayling as for juvenile chinook salmon.

GLLFAS and FWI-Industry is developing volumes of monitoring data, and each portion could be valuable over time. It is important to recognize that low (very low) quality monitoring data may be supplied by industry because they are not required to do good science-based work. The provision of data could be made a condition of a HADD authorization. With respect to most compliance monitoring reports, nothing is done with them from an analytical perspective. Current monitoring requirements that are attached to authorizations and licenses are of limited value. Habitat monitoring should consist of data collection, using control sites, as, for example, the Panda Diversion Channel research (BHP Billiton) – a scientifically-designed program.

GLLFAS and FWI-Habitat Management needs advice from DFO Science to direct industry on what data to collect and for what purpose. DFO requires a mechanism and the appropriate expertise to get experimental design and replication right, so that the results of the work will withstand rigorous scrutiny. Diamond mining companies have offered to bring DFO and/or consultants together for advice on the design of monitoring and research. Monitoring will be over 25 years or more at diamond mines, so there needs to be an adaptive approach during this time.

GLLFAS and FWI-The interpretation of data is important, and especially that which is related to understanding how productivity occurs. For example, biomass may be constant within a lake but fish size may be decreasing. There is a core connection between production and habitat that needs to be understood.

13. Habitat policies and management

BHP Billiton-We support the POE approach. The Risk Management Framework has merit; POE will be very useful from Industry's perspective in that it is transparent, clearly identifies the decision-making framework, and enables us to focus on mitigation.

De Beers-Actions should be based on a risk approach.

Diavik-Regarding limitations to growth, society's view has the greatest effect. There is interest on the community side to understand the science, and with a progression towards self government there will be a need for this information and understanding. It is likely that there will be more Aboriginal control over time.

Klondike Placer Miners' Association-There are economic limitations in every industry. Also limiting are gold reserves.

Klondike Placer Miners' Association-Many operators are now mine planning 10 to 20 years ahead in order to ensure recovery of the increased capital investment. This tends also to limit the available reserves to existing operators.

Klondike Placer Miners' Association-Expansion of the industry will be constrained by the very limited new reserves.

Klondike Placer Miners' Association-Future growth of the industry even with strong price incentives may well be significantly constrained by the current level of regulation.

Canadian Natural Resources Limited-There is also no valid mechanism of incorporating traditional knowledge into some of these assessments.

Canadian Natural Resources Limited-The limitation to growth today is acceptance and authorization by the federal Responsible Authorities, primarily DFO.

Suncor-In my opinion there are currently no limitations to the planned growth of the oil sands industry in the Fort McMurray area.

Albian-The Alberta government has a sustainable-development ministry which ensures that we grow a commercial forest.

Albian-We should be able to compensate for disturbed habitat with money. We need to compensate in other environments that are more productive than at mines where there is mineralization and low aquatic productivity.

Albian-The use of wilderness areas is a major issue.

Albian-With Fort McKay elders we are trying to use traditional ecological knowledge (TEK) to restore habitat and to "heal" the land.

Albian-The world's demand for oil will ensure that the industry here continues to expand. Industry recognizes the need to reduce our water use. There are limits to growth and attitudes are changing.

Albian-There are limited financial resources. Industry on the one hand has a commitment to society and to science, but those same industry people hate wasting money. At the same time scandals in government reveal a poor record of money management.

Golder-The biggest information need from DFO, by far, is direction and a protocol for dealing with its Policy for the Management of Fish Habitat (the "Policy"). This, in turn, leads to what DFO should consider its research priority. The Policy is based on the concept of maintaining and ultimately enhancing the productive capacity of fish habitat in Canada. However, there is no direction or consensus even among DFO practitioners on how to achieve this goal. There is a dire need for a standardized, transparent, defensible method to address the harmful alteration, disruption or destruction of fish habitat, as a HADD is virtually unavoidable with oil sands developments.

Golder-Once a method of determining a HADD is available and used, the next challenge is adopting a method(s) for valuing loss and determining appropriate compensation.

Golder-Direction is required from DFO on how to achieve the Policy objective of a net gain in fish habitat in these situations. The interpretation of how this objective may be met in these pristine areas varies with the DFO practitioner involved.

Johansen-Species that are listed provincially or in SARA are of concern. Special consideration is also given to those populations that are unique.

Johansen-If one was to follow the Habitat Policy and the current guidelines then whole lake destruction would not be authorized because it results in the loss of critical habitat that can only be authorized in rare circumstances and is required to be compensated for at or near the site of loss. As far as I am aware there has been no successful compensation undertaken for the loss of a fish-bearing lake.

Johansen-If one was to follow a Pathways of Effects approach to major developments impacting fish habitat, it would falter on the issue of unavailability of technically-feasible compensation options. Similarly if one were to take the Risk Management approach using the Risk Assessment Matrix, destruction of a fish-bearing lake would clearly fall into the red zone which is "significant negative effects." With that as an outcome, what do we do with it?

Johansen-If DFO approves it at that point then it is clearly not based on any technical or science-based arguments. My recommendation is that DFO take the position that we are generally not supportive of whole lake destruction.

Johansen-It should also be communicated that every proposal that includes whole lake destruction, if considered by DFO, will automatically be sent to a panel review under CEAA.

Johansen-With respect to whole lake destruction, the magnitude of impact and the unknowns/risks associated with such a proposal make it difficult, if not impossible, to propose a mechanism to ensure that DFO policy is met.

Johansen-I would argue that the Habitat Policy is intended for smaller habitat losses where the impacts are understood and quantifiable and the proposed compensation has a reasonable chance of success and where the consequences of failure are manageable. To suggest that the same policy and approach can be used for a small stream reach and an entire lake is not reasonable. At some point the level of complexity becomes so great and the impacts so large that it is not physically, economically or biologically possible to compensate for habitat impacts. The decision to destroy a lake or other large system is no longer based on technical arguments and becomes a political, social or separate policy decision.

Johansen-There needs to be a separate policy or departmental position that comes into play when a project proposes to destroy habitat of the magnitude seen with whole lake destruction.

Johansen-The authorization/compensation part of the Habitat Policy focuses on the component parts of an ecosystem – not on entire ecosystems.

Johansen-In the Pacific Region there is the Watershed Fish Sustainability Planning initiative that promotes an "ecosystem-based" decision-making system.

Johansen-For decision making regarding habitat impacts, we use the Habitat Policy (1986), the HADD Decision Framework (1998), the C&P Guidelines (1998) as well as the wealth of professional experience and judgment available from the habitat assessment biologists. Large mining projects are always reviewed as part of joint federal/provincial review process that operates in accordance with the Canada/BC Agreement on EA Co-operation. CEAA requirements are met through this harmonized process.

von Finster-Through the Yukon Placer Agreement (YPA) there is a formal decision-making process based on the classification of streams. With Type Di streams, it means that there is a water quality deferral. Type Dii streams can have a habitat deferral. To date, all deferrals have been water quality deferrals, which means that under the YPA, discharges are based on a dilution model – a sediment level deferral. There have not been any type Dii habitat deferrals. Streams that do get diverted are largely Type IV streams. These streams could have high populations of fish, but unless the Yukon Placer Committee (YPC) agrees that they support a fishery, or a defined salmonid, they can be written off. When an authorization is issued, DFO has management steps to follow: authorization, compensation, and monitoring/evaluation.

von Finster-In terms of geographic extent, just under 10% of the watershed area of the Yukon River within the Yukon Territory upstream of the US border drains into Type IV streams or into streams with water quality deferrals.

von Finster-Compensation in-kind was thought to be universally achievable and effective in the 1980s. We need to think past that. Where there is a stable environment, then on site compensation-in-kind, as per the 1986 Habitat Policy, is OK. But in unstable areas, create more off-channel habitat, rather than like-for-like, and provide for food production, juvenile cover and support to other life history stages. If we consider that diversity is good, why do we have to have like-for-like?

von Finster-The new placer mining management regime is being discussed. The new management regime may have components of compensation and restoration in it, but first we have to build trust working with the operators.

Dahl-Yes, there is a formal process engrained in policy in DFO for habitat harmful alteration, disruption or destruction (HADD). There is also a DFO HADD determination document.

Shamess and Majewski-In Alberta, DFO is responsible for fish habitat and the Province is responsible for the management of the fishery. The habitat is managed in accordance with fishery values.

Shamess and Majewski-The Alberta oil sands (AOS) mine projects require both federal and provincial environmental assessment reviews. The Environmental Impact Assessment (EIA) report is written by the proponent.

Grant and Dawe-There is an informal decision-making process whereby HM staff conduct habitat assessments.

Gordanier and Moggy-There is no formal decision-making process that we are aware of specific to Eastern Arctic. Informal decisions are based on information provided by the proponent and the expertise of the biologist reviewing the file.

Merkowsky-We generally follow the HADD decision framework as outlined in 1998 document Framework for the Determination and Authorization of HADD of Fish Habitat. The possible impacts of the components of the project are considered in relation to a number of sections of the *Fisheries Act*.

Merkowsky-The amounts (calculated by area) of fish habitat that are being harmfully altered, disrupted or destroyed are quantified during the review process. These amounts are then identified in the authorization of the HADD.

Rudolph and DeBruyn-In Ontario, staff reference DFO publications such as the "Decision Framework for the Determination and Authorization of Harmful Alteration, Disruption or Destruction of Fish Habitat" (Fisheries and Oceans Canada 1998) and the Department of Fisheries and Oceans (1986) "Policy for the Management of Fish Habitat" during the decision-making process. OGLA staff also seek advice from DFO scientists (primarily from CCIW and FWI, but also other DFO scientists, academia where possible expertise exists), senior habitat managers, Environment Canada, and Ontario Ministry of Environment. Ontario Ministry of Northern Development and Mines is also available to project reviewers.

Rudolph and DeBruyn-OGLA has established under the Habitat Operations Council, a Mining Task Group.

Rudolph and DeBruyn-To set OGLA programs in the best position within the auspices of chapters 3 and 4 of the Habitat Policy and work towards sustainable development with provincial agencies and proponents from different mining and exploration sectors, the Task Group was established to begin building that information-assembly process.

Bérubé-An analysis is performed in which impacts are assessed in terms of habitat productive capacity, based on the size and functions of the habitats affected for the various species present in the affected areas. Managers are notified of the possible impacts of a project with a view to decision making. Generally, this fits into the environmental assessment context under the *Canadian Environmental Assessment Act* (CEAA), and a report (screening or comprehensive study) is prepared with recommendations for mitigation measures. An assessment is conducted early in the process to determine whether the project must be referred to a public review panel.

Bérubé-Uncertainty is incorporated into the decision-making process by applying precautionary principles and professional judgement (to the best of your knowledge).

Levings-The 1986 Habitat Policy should really be revisited and tuned up with a strong emphasis on fish habitat planning, which is actually written into the Policy but is not very often used. As well, habitat scientists and managers need to become much more aware of the growing literature on landscape ecology as it relates to fish populations and how habitats are inter-dependent. In my view if we actually planned compensation works with this concept in mind we would be advancing a more scientifically-defensible methodology.

GLLFAS and FWI-The lack of a fishery is not grounds for devaluing fish habitat.

GLLFAS and FWI-Economic factors force us to keep our options flexible, but perhaps Canada should take a firmer position with diamond mines to ensure they clean up progressively as they develop their mines and fill a previous open pit with waste material from the next pit being mined.

GLLFAS and FWI-Northern Aboriginal communities have tended to resist fish habitat compensation measures by humans in pristine areas of the north. If mining for diamonds and the inevitable changes to land and water are accepted, then perhaps enhancement measures should also be accepted in pristine areas to offset losses to fish habitat and fish caused by the mining development. Linked to this issue is a need to give more thought to the benefits to Aboriginal communities and any fisheries through fish habitat compensation measures that are associated with mining developments.

GLLFAS and FWI-A habitat management plan pre-supposes that there are fisheries objectives for this area. However, we rarely get beyond the exploitation objectives of users. A habitat management plan is a plan to conserve, and to meet fisheries management objectives. At Diavik the habitat compensation plan included all fish species. A proportional composition table of species was developed and it addressed DFO objectives. DFO needs to articulate fisheries objectives for industry. It is DFO's responsibility to develop fishery targets, with species and numbers, with a view to protecting stocks into the future. Where there are administrative agreements to manage the fishery, provincial partners need to be included in decision making.

14. Communication, guidelines and information transfer

BHP Billiton-In order for exploration to occur, industry needs the ability to assess large blocks of land efficiently without onerous permitting. Exploration for diamond mining in Canada has been hampered or delayed due to concerns over potential impacts. DFO keeps raising these concerns about sediment, so could DFO quantify its concerns and confirm them?

BHP Billiton-It seems impractical that every exploration company should have to prove there will not be any impact from a "common activity" such as drilling. It would be helpful if DFO could contribute to this.

Dahl-Opportunities exist with Diavik's lake and stream enhancement work on East Island. Science input is needed. We just need the tools, such as a monitoring for success guide, and a standard habitat assessment guide (how to focus assessment of habitat to get the right outputs). There is also a need for standard habitat assessment protocols.

Shamess and Majewski-What performance measures can be used to evaluate compensation success and ecosystem integrity?

LAKE ELIMINATION, TAILINGS IMPOUNDMENT AREAS (TIAs), AND THEIR REGULATION

The following comments provide details regarding the destruction and degradation of lakes for mining in Canada since the 1950s and the associated compensation and restoration required by DFO. The list includes lakes that have been partially or totally eliminated for mining. Seventy lakes or parts of lakes, plus numerous streams, mostly in northern Canada, have been, or are proposed for elimination. This has enabled mines to use natural, fish-frequented lakes as tailings impoundment areas (TIAs), pit water management basins, or to obtain access to ore or granular construction materials. The numerous streams that have been, or are planned to be, eliminated or diverted for TIAs and other aspects of mining, including that for oil sands, have not been identified.

METAL MINES WITH TIAs SCHEDULED IN MMER

Hudson Bay Mining and Smelting Company (Snow Lake Mine), MB (1 lake)

In 1978 DFO authorized the use of Anderson Lake as a TIA at this base metal mine. The lake was described as having "no significant fishery" in the DFO designation document. The sulfide-containing tailings were considered to be acid generating. Fish habitat compensation was not required of the proponent given that the development predated the Policy for the Management of Fish Habitat. This TIA is 1 of 5 listed in Schedule 2 of the MMER and is still in use.

Cominco (Polaris Mine). Garrow Lake, NU (1 lake). (MMER includes it in the Northwest Territories)

DFO authorized the use of Garrow Lake on Little Cornwallis Island as a TIA from 1981 until the mine closed in 2002. The lake, which was described as having stagnant bottom water below 20-m depth that is devoid of dissolved oxygen, supported only "sculpin and lower aquatic life forms" above 13-m depth. Thickened tailings were to be discharged below the halocline at a depth of at least 26 m. Fish habitat compensation was not required of the proponent because this designation, like the one for Anderson Lake, predated the Habitat Policy.

Kemess South Mine, BC (streams)

In 1996, DFO authorized a 44-ha TIA in a valley that contained streams with fish. To offset the damage to fish habitat, the company was required to construct stream, pond and side-channel habitats, a fishway, specific spawning areas, and fish passage at beaver dams for transplanted dolly varden. It was also intended that bull trout were to benefit from these measures. Habitat compensation effectiveness monitoring and reporting is continuing at this location.

Homestake Canada Inc. (Eskay Creek Mine). Albino Lake, BC (1 lake)

In 1997, DFO designated this alpine lake as a TIA for a gold, silver and base metal mine, but the Department required no fish habitat compensation because the lake was fish-less.

Homestake Canada Inc. (Eskay Creek Mine). Tom MacKay Lake, BC (1 lake)

Similar to Albino Lake, Tom MacKay Lake is also a high alpine, fish-less lake, which was designated as a TIA for the same gold, silver and base metal mine in 2000, without any fish habitat compensation.

OPERATING METAL AND DIAMOND MINES INVOLVING WHOLE OR PARTIAL LAKE DESTRUCTION

Iron Ore Company (IOC). Wabush Lake, NL (1 lake; part of 1 lake; streams)

IOC began discharging iron mine tailings into Wabush Lake in 1962. By 2011, the company is required to complete the confinement of its tailings inside a 15-km dyke within Wabush Lake. Compensation is to be provided to offset the HADD caused by the confinement dyke and the tailings through construction of spawning and rearing habitat on the outside face of the dyke, and through the confinement of tailings, consolidation of discharges, and routing of all tailings to the confinement area. In addition, sediment-laden discharges will cease in the area of Beaver Bay Basin with consolidation of all discharges and routing of same to the tailings confinement area. A monitoring program is to be conducted by IOC on the stability of habitats, changes in productive capacity, utilization of habitats, and structural integrity of the compensation works.

In order to access iron ore reserves, IOC de-watered Hakim Lake and Hakim Brook and diverted the outlet stream of White Lake around the pit. This resulted in a loss of 12.2 ha of lacustrine habitat and approximately 45 units (habitat equivalent units;1 unit = 100 m^2) of riverine habitat. The compensation plan consists of increasing the productive capacity of White Lake (a fish-less lake) through the relocation of fish from Hakim Lake and Hakim Brook to White Lake and the creation of spawning and rearing habitat via construction of a channel at the outlet of White Lake. The plan also provides for the creation of salmonid spawning and rearing habitat at Tinto Brook, along with modifications of the Tinto Brook culvert to provide fish passage to Wabush Lake. Prior to the compensation works being undertaken, IOC was required to conduct baseline studies to ensure that White Lake was fish-less and could also maintain a viable fish population. Compensation monitoring will be required until 2011. Preliminary results to date indicate that fish transferred from Hakim Lake have been utilizing the newly-created White Lake outlet.

Wabush Mines, Flora Lake, NL (1 lake)

The Wabush iron ore mine has been discharging tailings into the South Basin of Flora Lake since 1965. To offset the loss of habitat associated with tailings disposal in Flora

Lake, Wabush Mines is required to undertake a compensation program beginning in 2005.

In consultation with stakeholders, Wabush Mines will conduct a series of lacustrine habitat restoration measures, and habitat creation and/or enhancement programs within Labrador over the next 5 years. In addition, Wabush Mines will enhance and improve riverine habitat in a diversion channel near Wahnahnish Lake and in the outlet channel of Albert Lake.

Monitoring of the lacustrine programs (enhancement, creation, and restoration) will be conducted over the next 5 to 10 years, as individual compensation plans are submitted and implemented. The monitoring program (2006-2012) for the enhancement of riverine habitat in the diversion channel and the outlet of Albert Lake will consist of electrofishing surveys to assess channel utilization and recruitment success, visual surveys for the presence of fry and young of the year, and visual surveys of spawning activity including the recording of gravid fish and the presence of redds. Assessment is also required of the structural integrity of channel enhancements, e.g. visual surveys to ensure stability of in-stream structures.

Québec-Cartier Mining Company (Mont-Wright Mine) Lac Hessé, QC (1 lake)

The existing tailings pond at this iron ore mine has been confirmed as being frequented by fish. Evaluation of fish habitat suitability is underway using the Standard Methods Guide: for the Classification/Quantification of Lacustrine Habitat in Newfoundland and Labrador. (Bradbury et al. 2001).

Campbell Resources Inc. (Copper Rand and Camchi Mines), Chibougamau, Lac Doré, QC (1 lake)

Tailings from this copper-gold mine are being discharged into fish-frequented Lac Doré. Evaluation of fish habitat suitability is underway using Bradbury et al. (2001).

QIT-Fer et Titane (Tio Mine), Lac Petitpas, QC (part of 1 lake)

This ilmenite (titanium ore) mine has been in operation since 1950. QIT currently disposes of its waste rock in Lac Petitpas, and is proposing to increase its waste rock disposal area to include an additional 6 ha of that lake. Evaluation of fish habitat suitability is underway using Bradbury et al. (2001).

Noranda, Matagami Mine, Lac Watson, QC (1 lake)

This unscheduled TIA is reportedly no longer fish frequented.

Cameco Corporation (Key Lake Mine), SK (6 lakes)

Six lakes were drained by 1981 in preparation for uranium mining that started at the Key Lake site in Saskatchewan in 1983. During development of the Deilman and Gaertner open pits, Key Lake, Lower Key Lake, Seahorse Lake, Hourglass Lake, Kathy Lake and Fred Lake were de-watered. As a consequence of disposing of the excavated mine rock in the drained lake bottoms, when de-watering ceases and the lakes re-establish, a substantial portion of the original Key Lake and a lesser portion of Hourglass Lake will have been eliminated.

INCO (Thompson Operations), MB (2 lakes)

The Thompson Mine started operations in 1958 with underground workings. In 1986, Thompson Lake was drained and open pit mining was commenced in the lake basin until the early 1990s, when open pit mining ceased. Tailings from the open pit, and currently from the underground mines, are discharged into a series of basins, culminating in Misery Lake, which discharges via Misery Creek into the Burntwood River.

Claude Resources Inc. (Seabee Mine) East Lake, SK (1 lake)

In 1992, DFO authorized the destruction of East Lake as a TIA. Damage to fish habitat was to be offset by construction of spawning areas for lake trout in nearby Porky Lake. This work was to be accompanied by an assessment of the effectiveness of the habitat compensation measures, and the program was to be modified as necessary to achieve no net loss.

The constructed reef in Porky Lake was assessed for a second time in October 2001 (the first time was in 1992). No lake trout eggs were collected at the constructed reef. Lake trout eggs were collected at a number of reference locations in Porky Lake (2001). The constructed reef had ninespine stickleback, lake chub, white sucker and burbot associated with it.

Cameco Corporation (Rabbit Lake Mine). Rabbit and Wollaston Lakes, SK (1 lake and portions of a second lake)

At the Rabbit Lake uranium mine, Rabbit Lake was eliminated for access to ore through open pit mining. Subsequently, the end pit was used as a TIA. In 1994, DFO authorized the destruction of two areas (A Zone and D Zone) of Collins Bay in Wollaston Lake for open pit mines (a third area of Wollaston Lake, B Zone, was reportedly also de-watered for use as a mine pit prior to 1994). Fish habitat compensation included the construction within Collins Bay of two lake whitefish spawning shoals (2,500 m^2 and 3,000 m^2) and of two pike spawning and rearing marsh habitats (7,600 m^2 and 2,000 m^2). Monitoring of the effectiveness of the compensation sites was required of the proponent. The pike spawning marsh habitats have been utilized by pike for spawning. The utilization has been somewhat lower in comparison to reference sites. This may change as the constructed marsh habitats continue to develop. Monitoring results were confounded by low water levels during the sampling years.

Utilization of the constructed whitefish spawning shoals has been limited but viable eggs have been collected at each of the shoals. Results have been confounded by failure to find a suitable reference site for comparison. The situation may be that the lake whitefish are utilizing a large stream for the majority of spawning. The proponent has now presented a number of options for reconnecting one of the restored pits with the main part of Collins Bay.

Claude Resources Inc. (Seabee Mine). Triangle Lake, SK (1 lake).

In 2002, DFO authorized a TIA in Triangle Lake (habitat for white sucker, lake chub, longnose dace, ninespine stickleback and slimy sculpin). Triangle Lake fish were captured using a variety of techniques and transferred (2277 fish survived) into Pine Lake under a provincial Transfer Permit. The company was required to focus its compensation efforts on improving habitat for lake sturgeon in the same watershed. In 2007, the company will have to submit a report on the status of the compensation measures.

BHP Billiton (BHPB) Ekati Diamond Mine, NWT (original project) (12 lakes + streams initially; after mine plan amendments: net loss = 11 lakes + streams)

According to the authorization issued to this diamond mining company, "To compensate for the loss of fish habitat associated with the Project, BHP Minerals shall implement the Fish Habitat Compensation Agreement negotiated between the Department of Fisheries and Oceans (DFO) and BHP Minerals." In accordance with this authorization which recognized that "The Project will impact directly on 12 lakes within the claims block," BHP placed $1.5 million into a Habitat Compensation Fund established and administered by DFO. The fund was to be used to support habitat compensatory projects (BHP also constructed the Panda Diversion Channel that diverts drainage water around active open pits and also provides stream habitat as part of the compensatory measures for development impacts on streams).

Six of the lakes were to be de-watered for access to the underlying kimberlite pipes, 1 for access to granular resources for construction, 4 were to be filled with process plant tails, and 1 was to be covered by a waste rock dump. However, in a January 2003 authorization, it was stated that BHPB no longer intended to proceed with the de-watering of Leslie Lake. Accordingly, there has been a net loss of 11 lakes together with streams that were identified in the 1997 authorization.

The DFO-established Fish Habitat Compensation Fund, supports projects proposed by an Aboriginal Advisory Committee set up by DFO. Although none of the projects conducted or proposed addresses diamond mining impacts, they do focus on potential habitat issues associated with road construction, barriers to migration, declines in fish numbers and fish quality, with a priority placed on community-based habitat restoration projects.

Lakes eliminated for diamond mining are drained and fished out according to a protocol designed to provide scientific data to aid future predictive assessments of lake productivity and fish yield. Compensation for damage to streams has involved the creation of fish habitat and habitat enhancement within an artificial diversion channel (the Panda Diversion Channel).

BHP Billiton (BHPB) Ekati Diamond Mine NWT (King Pond) (1 lake + streams)

In 2000, BHPB was authorized to use King Pond as a mine water settling facility for the Misery Pit. The company was also authorized to dam King Pond (Arctic grayling habitat, 29.1 ha, maximum depth 2.5 m) and harmfully alter King-Cujo Streams which drain it. Habitat alteration involved the loss of migratory access to King Pond habitat from downstream because of a dam; reduction in King Pond water quality; and the deposition of sediments. The authorization is to be valid until December 31, 2015. To rehabilitate and enhance fish habitat in King Pond and King-Cujo Streams upon completion of mining at the Misery Pit, the company is to remove sediments within King Pond, increase its depth for fish over-wintering habitat, increase its habitat diversity, re-establish its outflow by partial dam removal, and enhance the drainage and migration corridor between King Pond and Cujo Lake.

BHP Billiton (BHPB) Ekati Diamond Mine, NWT (Desperation Pond) (1 lake + 1 stream)

The Desperation-Carrie Complex is a headwater aquatic system that drains into Lac de Gras. Via a 2002 authorization that is valid until 2015, BHPB can use Desperation Pond (7.1 ha that provides for "Arctic grayling spawning, rearing, forage and overwintering") for waste rock storage, and pit water management, through construction of a dyke in Desperation-Carrie Stream (75 m of Arctic grayling spawning, rearing, forage, and migration habitat). A habitat compensation and monitoring plan is being finalized.

Diavik Diamond Mines Inc. (DDMI), NWT (6 lakes + part of an additional lake + streams)

The DDMI Project is centered on 20-km^2 East Island in Lac de Gras, 30 km SE of Ekati, and intrudes into Lac de Gras.

An authorization issued in 2000 that is valid until 2025, allows DDMI to destroy six East Island lakes, stream habitat on East Island, and habitat within Lac de Gras. To offset the loss of the Island lakes, compensation includes construction of connections among mainland lakes m1, m2 and m3; and enhancement of one East Island lake for an overall compensation ratio of 1.5:1. For loss of stream habitat on East Island, the company is required to enhance West Island Stream ws1 and incorporate habitat features in a connector stream constructed between m1 Lake and m3 Lake on the mainland. To offset damage in Lac de Gras, the company is required to develop shallow rearing habitat, spawning shoals and shoreline habitat within the dyked areas around the open pits in Lac de Gras upon completion of mining in each open pit, and ensure that habitat features within the dyked areas upon completion of mining in each open pit are modeled after those features found in other productive areas of the lake.

De Beers Canada, Snap Lake Project, NWT (1 lake + 1 stream)

The phase of the impact referenced below is completed, however the mine is not scheduled to be in production until 2007.

In 2000, DFO authorized the destruction of Lake IL1 and Stream S30 for the development of a TIA. Lake IL1 (2.53 ha) was dammed, destroying Stream S30 (490 m). Compensation focused on increasing the productivity of Snap Lake because it is more accessible to fish than smaller systems. Because lake trout spawning habitat is believed to be limiting in Snap Lake, two spawning shoals, each with a footprint of no less than 100 m^2, are required, one of which has been completed and is now being monitored. Effectiveness monitoring with control sites is required for 3 consecutive years.

PROPOSED DIAMOND MINES INVOLVING WHOLE LAKE AND STREAM DESTRUCTION, INCLUDING TIAs

BHP Billiton (BHPB) Ekati Diamond Mine Expansion, NWT (5 lakes + 1 stream)

In 2003, BHPB was authorized to destroy Sable, Two-Rock and Beartooth Lakes; Pigeon and Big Reynolds Ponds; and Pigeon Stream.

BHPB is required to remove the fish from Sable, Beartooth and Two-Rock Lakes, and provide a written report of the results of the fish-out programs, including all biological data as per an agreed-upon protocol.

The section 35(2) authorization is for 614,700 m^2 of lake habitat and 840 m^2 of stream habitat, valid until December 31, 2007. More specifically the authorization allows: the de-watering and stripping of bottom substrates of Sable Lake (87,900 m^2); construction of a dam across the outflow stream-lake transitional area of Two-Rock Lake; de-watering of Two Rock Lake and construction of an intermediate dyke across Two-Rock Lake, and use of Two-Rock Lake (292,900 m^2) as a sedimentation pond; de-watering and stripping of the bottom substrates in Pigeon Pond (10,000 m^2) and berm construction and removal of water from Pigeon Stream (reaches 3 and 4, 840 m^2); placement of waste rock in Big Reynolds Pond (174,100 m^2); de-watering and stripping of bottom substrates of Beartooth Lake (48,800 m^2), and construction of a jetty and associated water intake pipeline development in Bearclaw Lake (1,500 m^2).

The Compensation Plan for the stream impact has not yet been submitted, but is due a minimum of two years prior to the start of construction.

Because BHP Billiton no longer intends to proceed with the de-watering and the resulting elimination of Leslie Lake that was identified under the 1996 authorization (pursuant to clause 7 of the 1996 Fish Habitat Compensation Agreement between DFO and BHP Billiton), BHP Billiton's compensation for larger Leslie Lake was transferred as compensation for the 5 smaller lakes that were subsequently approved for destruction in 2003. Regarding stream habitat, BHP Billiton is to compensate for the destruction of reaches 3 and 4 of Pigeon Stream through the implementation of compensation plans that have yet to be developed. Compensatory habitat is to be provided at a ratio of 2:1 for the lake trout, slimy sculpin, burbot, and Arctic grayling habitat that will be destroyed. Success at implementing the compensation plans will be considered achieved when permanent habitat unit (HU) gains offset losses at a ratio of 2:1. According to Regional Habitat Management, plans for the enhancement of biological productivity have been stalled pending resolution of issues with communities which are not supportive of such measures.

Monitoring plans for stream fish habitat compensation are to be developed by BHP Billiton, in consultation with affected Aboriginal communities, and submitted to DFO for review concurrent with submission of the compensation plans. The monitoring plans, subject to DFO approval, are to be implemented with the intent of acquiring data and quantifying whether the compensation habitat meets the 2:1 habitat unit gains to losses ratio and is functioning physically and ecologically as intended.

Tahera Diamond Corporation (Jericho Project), NU (3 lakes + streams)

The mining company has proposed to use Long Lake and two associated ponds as a processed kimberlite containment area (PKCA – tailings impoundment area) for the extraction and production of diamonds south of the Jericho River system. Habitat losses include the 10.0 ha Long Lake (which supports slimy sculpin and burbot), two unnamed ponds adjacent to Long Lake (1.0 ha also supporting slimy sculpin and burbot; and 0.7 ha supporting slimy sculpin), the diversion of Stream C1 and the construction of a water intake causeway. Habitat losses and gains are quantified through the use of a Habitat Suitability Index, similar to the approach used at BHPB (for Sable, Pigeon and Beartooth Lakes). Using this model, the ratio of gains to losses is predicted to be approximately 2:1. Habitat compensation is to target the construction of high quality spawning, rearing, foraging and wintering habitat for resident species of fish, including Arctic grayling, Arctic charr, lake trout, burbot, slimy sculpin and round whitefish.

PROPOSED METAL MINES INVOLVING WHOLE LAKE AND STREAM DESTRUCTION, INCLUDING TIAs

Voisey's Bay Nickel Company Ltd. Headwater Pond, NL (1 lake + part of a stream)

In 2003, DFO issued a section 35(2) authorization associated with the construction of a dam and the disposal of tailings and waste rock into Headwater Pond (Arctic charr and brook trout habitat), and flow reduction in Camp Pond at Voisey's Bay, Labrador. To offset the loss of this habitat (90 ha of lacustrine habitat equivalent units and 58 units of spawning and rearing riverine habitat) over the next five years, the company is to conduct restoration project(s) of physically-degraded riverine fish habitat within Labrador in consultation with Aboriginal communities. In addition, the company is required to conduct baseline studies and increase the productive capacity of Pond 61, a fish-less lake, through the relocation of fish from Headwater Pond.

Biological studies on Headwater Pond Arctic charr and brook trout will be conducted as well as fish and fish habitat baseline studies on Pond 61. Headwater Pond Arctic charr and brook trout will be measured and marked prior to release in Pond 61 and visual surveys of Pond 61 are to be conducted to determine initial survival of transferred fish. The company is required to conduct a 5-year monitoring program on restored riverine habitats including quantifying habitat gains. As well, a ten-year monitoring program is to be carried out to assess the increase in productive capacity of the enhanced Pond 61. The monitoring program to assess the increase in productive capacity of Pond 61 is to include the following: visual surveys of Arctic charr and brook trout spawning in Pond 61 including the outlet, any associated tributaries, and gravel bars, upwellings; recording of the presence of gravid fish and the number of redds; visual surveys for the presence of fry and young of the year Arctic charr and brook trout in Pond 61 and Pond 61 outlet and/or its associated tributaries; electrofishing survey in Pond 61 outlet and its associated tributaries to assess recruitment success, and fish sampling programs to estimate population size and the condition of fish.

Miramar Mining Corporation (Doris North). Tail Lake, NU (1 lake)

This proposed gold mine would result in the loss of Tail Lake as a TIA. The proposal from the company stated that Tail Lake would be taken out of biological production as it would receive all process tailings and treated sewage from the mine (34.8 HUs would be lost).

It has been suggested by the company that compensation would include increasing accessibility to nearby Roberts Lake and stream enhancement in Roberts Outflow, which, combined, could potentially provide 132.85 HUs. This would be expected to result in a 1:3.8 ratio of habitat loss:habitat gain. Additional compensation would include the creation of rearing habitat in Doris Lake and stream habitat enhancement in a tributary to Roberts Lake. The natural water flow in Tail Lake outflow would be disrupted by the tailings dam, which would be compensated for by enhancement of rearing habitat in Doris Lake. A proposed dock in Doris Lake would be offset by the creation of rearing habitat. A proposed jetty in Roberts Bay would be offset by rock spurs and riprap along a jetty and shoreline.

Cumberland Resources Ltd. Meadowbank Gold Project, NU (arm of 1 lake)

In January 2005, Cumberland submitted its Aquatic Ecosystem/Fish Habitat Impact Assessment Report for a proposed gold mine located 70 km north of Baker Lake, Nunavut, with an expected life span of 8-10 years. The environmental assessment phase was expected to be concluded in mid 2005, to be followed by the regulatory phase. The company has proposed to use a 93-ha portion of Second Portage Lake (46% of the volume of the lake) as a tailings impoundment area.

Tyhee Development Corporation, NWT (1 lake)

This proposed gold mine (expected life of 8 years) is located near the previously-operating Discovery Mine, about 90 km north of Yellowknife. The proposed TIA is Winter Lake, which has a surface area of approximately 69.2 ha. Fish use of Winter Lake was to have been assessed in the summer of 2005. Land Use Permit and Water Licence applications have been submitted to the Mackenzie Valley Land and Water Board, which was to conduct a preliminary screening of the development proposal.

Northgate Minerals Corporation (Kemess North Project), BC (1 lake)

The proposed Kemess North open pit copper-gold mine is located 5.5 km north of the South Kemess mine and mill complex in northern British Columbia, and, if permitted, would allow an additional 10 years of mining to occur as the existing mine is phased out.

The company proposes two options for disposal of 850 million tonnes of waste rock and tailings. Option 1 would use Duncan Lake as a TIA – a 5.5-km long, 242-ha lake supporting rainbow trout, dolly varden and mountain whitefish. This would require constructing ~100-m high dam at the north outlet, a 30-m high dam at the southwestern end of the lake to contain the volume of mine waste material. Option 2 would use multiple land based storage sites. This would necessitate the construction of large containment dams and the augmentation of existing facilities at the Kemess South mine to contain the mine waste material.

Northgate has stated that using Duncan Lake is the only economically-viable solution for the disposal of mine waste. In addition to the destruction of the lake, using Duncan Lake as a TIA would likely have impacts on the downstream Attycelley Creek watershed due to required de-watering of the lake for dam construction and due to flow changes.

Local First Nations have stated that the lake and watershed support occasional native fishing activities. Northgate has proposed a list of "technically-feasible" compensation options that could be combined to form an overall compensation package. These include transplanting fish to unutilized lakes, construction of a fish ladder, access channel, rearing channel, and spawning platforms, damming a valley to create lake habitat; and reduction of natural acid rock drainage.

Red Chris Development Co. Ltd., BC (fish-bearing stream and a non fish-frequented lake)

Red Chris copper-gold open pit mining and milling project in northwestern BC involves the construction of a Y-shaped TIA by damming the headwaters of Trail Creek, Quarry Creek and an unnamed creek, resulting in the loss of approximately 4650 m, 1150 m, and 250 m of stream, respectively (note, this does not include the footprint of the dams). Although fish frequent each stream, reportedly only a 650-m section of Trail Creek is fish-frequented (rainbow trout) within the proposed TIA. Beaver activity in Trail Creek currently prevents upstream fish passage into the upper headwaters, which includes approximately 4,000 m of stream and wetland, and Black Lake (7.74 ha). The project would divert water from the Trail Creek watershed (Iskut River system) and discharge supernatant from the TIA into Quarry Creek during operations, and the unnamed creek during closure, which both ultimately drain into the Klappan River. The company is hoping to commence production in the 4th quarter of 2006.

Aur Resources Inc., Duck Pond Project, NL (2 lakes).

The Aur Resources copper-zinc project in central Newfoundland involves the use of two natural, fish-frequented lakes: Trout Pond (28 ha) and the headwater pond of a tributary to Gill's Pond Brook (1.0 ha) as a proposed TIA. The proponent was negotiating fish habitat compensation with DFO in order to offset the loss of productive capacity in these lakes. The mine would be expected to operate from late 2006 until 2014.

McKenzie Bay International Ltd. (Lac Doré) Vanadium Project, QC (at least 11 lakes and several streams).

The proposed Lac Doré open pit vanadium mine is located 27 km SE of Chibougamau. The site straddles the divide between the James Bay Watershed and the Saint Lawrence River watershed. If permitted, the proposed mine is expected to produce high purity vanadium-based electrolyte for vanadium redox battery technology over a period of 20 years with the possibility of expanding the operation for another 20 years. The following accounts for the first 20 years.

The company proposes two waste rock disposal sites (north and south) in natural depressions for a proposed volume of 40 million cubic metres. The south site would result in the destruction of an 8-ha headwater lake that drains toward Lac Jean. The north site would cut off Lac Laugon and Lac Coil from Villefagnan Stream. Waste rock would be transported to the disposal sites by truck, thus requiring the construction of appropriate roads. Process tailings from the mill would be deposited via pipeline into the Rivière Boisvert watershed. The proposed impoundment area would cover an area of 350 ha and would be contained by 15-m high dyke, resulting in the destruction of Lac Chauve-Souris (3.75 ha), 3 unnamed lakes (total of 3.2 ha), and 3.5 km of Sable Stream, as well as cut off Lac Coco from the rest of the watershed. The mill operation requires the use of 400 m^3/h of water that would be extracted from Lac Brigon, resulting in a significant reduction of water levels in that portion of the Rivière Boisvert watershed. Main fish species include, brook charr, northern pike, burbot, lake whitefish, walleye and perch. A limited Aboriginal fishery exists in the immediate area of the project. Lake Chibougameau, located approximately 10 km downstream from the TIA, supports a sport fishery.

Proposed compensation involves blasting a waterfall in Villefagnan stream to allow walleye to access 5,875 m^2 of potential habitat.

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RECENT FISHERIES AND OCEANS RESEARCH RELATING TO PLACER MINING

Science staff carried out research in the late 1990s to assist in the understanding of the ecology of species in northern Canada and to provide information on sediment effects. Two topics were considered, and the following comments outline some of that work to exemplify the type of focused yet basic research that has merit for enhanced understanding and assistance to decision making. The topics of the research were: the ecology of juvenile chinook salmon and their use of non-natal habitat (i.e. water where they were not hatched), and an examination of the responses of juvenile chinook salmon to sediment.

SEDIMENT EFFECTS

Exposure of chinook salmon to sediment affected their escape fright response, and marginally affected their susceptibility to predation. However, in more recent research, there were no demonstrable effects on the growth, feeding, biochemistry and behavior of juvenile coho salmon exposed to mean sediment levels that were <5 mg/L, over a 6.5-month period (Birtwell et al. 2003).

There was increased impairment of the feeding behavior of chinook salmon with increased sediment concentration (>0-1000 mg/L) and greater impairment with increased duration of exposure (determined at 3 and 9 weeks). Chinook salmon feeding efficiency on surface prey was impaired compared to that of control fish in the 3 sediment concentrations tested.

Chinook growth was impaired at all sediment concentrations tested above the clear control water, but the fish grew. The growth of the juvenile salmon fed a commercial sinking ration was impaired by exposure to sediment, but the fish still grew. The behavior of chinook juveniles to gather food from the bottom, mid water and surface of their habitat (in contrast to the typical feeding behavior of some other fish such as Arctic grayling), ensured that, over sufficient time, they could gather enough food for growth, even in the highest sediment concentration used (1000 mg/L). However, in nature the opportunity to feed is quite different than that in the laboratory, and elevated sediment levels reduce the bottom-dwelling food organisms that are typically preyed upon by the juvenile salmonids. Impoverished food resources typically occur in sediment-laden streams so it is likely that there will not be an abundance of food in such systems and that feeding opportunities on bottom-dwelling organisms will be significantly reduced (the literature contains much information of this topic). Feeding by sight on organisms in the water column and on the water surface is significantly impaired at low sediment concentrations. It was deduced therefore, that juvenile chinook salmon would be able to feed and grow in waters with sediment concentrations as high as 1000 mg/L as long as they were given sufficient time and food resources. Unfortunately both of these are very improbable.

Because elevated levels of suspended sediment have been shown to adversely impact prey items for these fish, it is highly probable that the diminished feeding efficiency of fish in turbid waters will, when combined with diminishing food resources, have a greater negative effect on growth, and hence survival, relative to fish in waters not so affected. These effects would be expected to be manifest at sediment concentrations less than 100 mg/L. Of practical concern here is the reduction in the productive capacity of headwater streams that may not have high fishery values or fish in themselves. These streams could be, and sometimes are, subjected to less stringent sediment discharge standards. Accordingly impacts in upstream waters will likely affect waters downstream and the organisms within them. Thus the degradation of upstream watercourses will not necessarily safeguard the fish and fish habitat in downstream reaches because sediment moves downstream in response to energy in the system.

Research on egg fertilization-suspended sediment interactions was conducted by testing the effect of suspended sediment on salmonid fertilization success (Galbraith, R., DFO, Cooperative Resource Management Institute, School of Resource and Environmental Management, Simon Fraser University, BC; unpublished data). Preliminary results suggest that suspended sediment concentrations greater than 2000 mg/L reduce fertilization success in sockeye salmon gametes (*Oncorhynchus nerka*), rainbow trout (*O. mykiss*), and coho salmon (*O. kisutch*).

Other research that has been carried out in recent years has tended to focus on the feeding of fishes and not specifically on their tolerance to sediment and survival. Sediment levels that are harmful to fish and their habitat are typically variable and relate to the species and life history stage. Low levels of suspended sediments (10s of mg/L) can harm fish. The significance of this harm is a topic for debate because of the subjective understanding of significance.

Our previous research had shown that Arctic grayling were a sensitive salmonid and studies in Alaska revealed that sac fry could be killed at concentrations of 22.5 mg/L over 48 h (LaPerriere 1988, cited in Anderson et al. 1996). On the other hand, juveniles survived exposure to thousands of mg/L suspended sediment, yet stressful circumstances evoked responses at much lower, tens of mg/L (McLeay et al. 1987).

One of the significant issues facing the regulation of sediment is that of the quantity of material discharged and its settlement in watercourses.

Sediment does not degrade, as does organic material. Fine material does settle out and remove/obliterate fish habitat (physical effects and food resources). In regard to this, Suttle et al. (2004) state that "although excessive loading of fine sediments into rivers is well known to degrade salmonid spawning habitat, its effects on rearing juveniles have been unclear." They examined the responses of juvenile salmonids and the food webs supporting them upon manipulations of fine bed sediment in a river. Increasing concentrations of deposited fine sediment decreased growth and survival of juvenile steelhead trout which were associated with a shift in invertebrates toward burrowing taxa unavailable as prey and with increased steelhead activity and injury at higher levels of fine sediment. "The linear relationship between deposited fine sediment and juvenile steelhead growth suggests that there is no threshold below which exacerbation of fine-sediment delivery and storage in gravel bedded rivers will be harmless, but also that any reduction could produce immediate benefits for salmonid restoration."

The experiments of Suttle et al. (2004) demonstrate that "fine-sediment deposition, even at low concentrations, can decrease growth and survival of juvenile salmonids." They found no threshold below which fine-sediment addition was harmless; thus they concluded "fine-sediment deposition in steelhead bearing rivers in this region will further impair this potentially population-limiting life stage, while land management practices that decrease fine-sediment loading or storage in channels may benefit salmonid populations."

Placer mine settling ponds often fail and therefore the material that has been kept out of streams is then discharged, thus negating the effects of containment. So containment practices often pose a problem for the maintenance of stream integrity.

While the discharge of low concentrations of suspended sediment may seem innocuous, the accumulation of the material and its secondary effect on light transmission and the reduction of aquatic productivity are potential effects of significance.

Comments regarding the effects of sediment on fish and their habitat

It is concluded that elevated levels of sediment (typically over background) may be harmful to fish (e.g. acutely lethal, or elicit sublethal responses that compromise their well being and jeopardize survival), and in addition, negatively impact on their habitat (Birtwell 1999).

Lethal levels of sediment, determined through laboratory experimentation over different durations of exposure, typically range from hundreds to hundreds of thousands of mg/L suspended sediment, whereas sublethal effects are typically manifest in the tens to hundreds of mg/L suspended sediment. Some species of aquatic organisms are more tolerant of suspended and deposited sediment than others (Lloyd 1987; Newcombe and MacDonald

1991; Caux et al. 1997), and this variation must be recognized when assessing potential effects.

Although elevated levels of suspended sediment elicit adverse responses in individual aquatic organisms, it is difficult to extrapolate effects to the population or ecosystem levels. However, the biological productivity of turbid systems has been shown to be less than that of non-turbid systems (Lloyd et al. 1987). Anthropogenic activities, such as some placer mining operations, have resulted in lowered densities of aquatic organisms in watersheds through the elevation of suspended and deposited sediments (refer to Alaska Department of Fish and Game 1987; Lloyd et al. 1987; Seakem Group Ltd. 1992).

Criteria, guidelines and recommendations, though having been formulated by different agencies, all tend to be mutually supportive. At the same time they have application limitations, especially relating to the protection of aquatic organisms from the effects of sediment concentrations in the ≤ tens of mg/L. Application of the criteria must be done while recognizing potential impacts on aquatic organisms at both the lethal and the sublethal level. Particle size and nature of the sediment must be considered as well. Bioassay information that reveals the lethal effect of sediment over a short period of time (such as 96 h) provides only a coarse indication of the effects of elevated levels of sediment in the wild. Accordingly, and when available, the more appropriate criteria which incorporate sublethal and lethal effects knowledge should be used.

Criteria documented in the report by Birtwell (1999) that are based on suspended sediment levels are appropriate and endorsed for use.

Recent guidelines have related elevated sediment levels regarding the natural hydrological regimes in streams and the associated variation in suspended sediment concentrations (Canadian Council of Resource and Environment Ministers, CCREM 1987; British Columbia Ministry of Environment, Lands, and Parks, BCMELP 1998; Canadian Council of Ministers of the Environment, CCME 1999). In addition, the use of risk criteria in relation to the elevation of sediment concentrations above background (Government of Canada 1993) have merit and are supportive of, and based on, earlier published criteria.

Models that utilize sediment concentration and duration of exposure to predict harm (Newcombe and MacDonald 1991; Newcombe and Jensen 1996; Caux et al. 1997; BCMELP 1998; CCME 1999) reveal significant trends in increasing harm to fish and other aquatic organisms with increasing duration of exposure. Such trend identification is of value in predicting the potential effects of sediment on aquatic organisms, but caution must be exercised when assessing the effects of low concentrations (≤ tens of mg/L) of suspended sediment over protracted periods of time. Furthermore, it is likely that there would be increased variation in the response among individuals and life stages of organisms to the effects of elevated, but lower and sublethal levels of sediments, relative to less variable responses at higher sediment levels; the latter being due to a greater severity of effect and less scope for adaptation, tolerance and resistance. Because of this, judicious application of these models is warranted when assessing the potential impacts of exposure to low levels of suspended sediment.

We concur with the conclusion of Seakem Group Ltd. (1992) regarding the inappropriateness of using Imhoff cone determinations (mL/L) to measure parameters (such as suspended sediment) that have been documented as valid entities in examinations of the effects of sediment on fish. The threshold for adverse impacts due to suspended sediments on fish and their prey organisms appears to be below the level of detection for the Imhoff cone currently being used in some instances to regulate sediment discharges from placer mines in the Yukon.

The settleable solids values for allowable discharges to Type II (Di - deferred), III (Di), and IV streams in the Yukon, are too high to protect fish populations and, indeed, allow discharges of sediments at concentrations which will almost certainly result in the destruction of food resources and denial of habitat. Our current research has provided new information on the levels of sediment (and the duration of exposure) that affect juvenile chinook. The results support the existing body of sediment-effects literature, and indicate that suspended sediment levels for the protection of fish and the integrity of their habitat must be <100 mg/L.

To protect fish and fish habitat in the Yukon, new regulatory standards are needed based on either suspended sediment concentration or turbidity, or a combination thereof. Furthermore, the application of models used to predict sediment discharge and receiving water levels must take into account the impact of loading for sediment, which unlike organic effluents, does not degrade rapidly. In addition the models must recognize and be sensitive to the natural hydrological-sediment regime and the nature of stream mixing, to ensure the protection of fish and the integrity of their habitat. In this context is the fundamental requirement to stabilize and restore watercourses upon the cessation of mining or after a predetermined period of time.

BIOLOGY OF JUVENILE CHINOOK SALMON

The absence or paucity of information on the ecology and biology of juvenile chinook salmon in the Yukon provided a limitation to understanding the habitat requirements of these fish and, accordingly, assumptions were included in decisions regarding the acceptability of habitat disruption for mining. One of those assumptions related to the use of non-natal streams which were considered for mining. Because of the misconception over their lack of significance to fish they were potentially subjected to elevated disturbance and sediment discharges.

M.J. Bradford (Fisheries and Oceans, Canada, Cooperative Resource Management Institute, School of Resource and Environmental Management, Simon Fraser University, BC) undertook studies to provide new knowledge on the ecology of juvenile chinook salmon. His research studies revealed that juvenile chinook did not rear in the Yukon River downstream of the significant input of sediment from the White River, and that the fish made extensive use of clear tributary, non-natal streams to feed and grow. He also recorded over-winter use of small, non-natal streams. Bradford has provided the following brief comments regarding this work.

It has been recognized for a number of years that juvenile salmon make extensive use of small, non-natal tributaries of larger rivers for rearing habitat, at least during the summer months. To further increase our understanding of the use of small streams studies were conducted from 1998-2001 in the Whitehorse, Minto and Dawson areas. The most intensive component of the study was completed at Croucher Creek, near Whitehorse, and that work is documented in Bradford et al. (2001).

The following is unpublished data from work conducted in the Minto and Dawson areas. The analyses are preliminary.

Fish use of non-natal streams

Fish were present in each of the 11 streams sampled in the summertime, and their densities appeared to be qualitatively related to the type of habitat in each stream. Fish densities greater than 0.8 fish/m^2 were found in stream with a well-developed pool-riffle structure, while streams with lower densities were either very shallow or contained little habitat complexity. Woody debris, in the form of fallen trees and root wads was an important feature of these streams as they provided cover for young salmon, and facilitated the development of small pools that were their preferred habitats (Mossop and Bradford 2004). Trees large enough to cause pool formation were at least 70 years old.

A comparison of the use of small tributary streams and the mainstem of the Yukon River

In the Fraser River, British Columbia, juvenile chinook salmon make extensive use of Fraser River mainstem habitats, and the densities of salmon found there suggest that the mainstem is a very important rearing area (Bradford, unpublished data). Sampling occurred in the Minto and Dawson areas of the Yukon River mainstem (areas that contrast in sediment loads: in the Minto area the suspended sediment concentrations are <20 mg/L during July and August, whereas in the Dawson area the loads range from 200-500 mg/L). In all cases the samples were taken from locations outside of the influence of tributary stream inflows.

Juvenile chinook salmon were relatively abundance through the summer months in the Minto area, but were not caught in the Dawson region. Similar results were obtained with electrofishing along the shorelines of the Yukon River.

Over wintering

The over winter use of small non-natal streams of the Yukon Drainage by underyearling juvenile chinook salmon is not well understood. Surveys were conducted in 1999-2001 in a variety of areas to document potential over wintering by young salmon. In some cases, captures were made in mid-winter through ice, but in most instances sampling was conducted in May, prior to the emigration of yearling smolts. Juvenile chinook were found in 33% of the 18 streams examined. Over wintering juvenile chinook salmon were found in most streams in the southern portion of the Yukon, but were absent from streams in the Dawson area.

Comment

Even at the relatively low adult escapements of recent years, juvenile chinook salmon appear to make extensive use of small, non-natal tributary streams in summer months. Juvenile salmon were found in the lower reaches of every stream sampled, unless there was a blockage from a windfall or beaver dam. It seems probable that the upstream distribution of salmon will vary annually because of changes in blockages, stream flows and fish densities. Bradford et al. (2001) provides detailed information on habitat use, and provides comparisons between the densities of fish in the Yukon streams and other chinook-producing areas.

Small streams appear to be essential fish habitat in the Dawson area during summer. We have not caught juveniles in the Yukon River mainstem, except at the mouths of creeks and rivers. It appears that the high sediment loads in this part of the Yukon do not result in conditions suitable for juveniles. It is unknown whether suspended sediment conditions in the mainstem are attenuated further downstream in Alaska such that juveniles use mainstem habitats in downstream areas. Some juveniles were captured in the Yukon River near Dawson in the fall months when suspended sediment levels are much lower – these fish may be the ones that leave the small non-natal streams in this area before freeze-up.

Juvenile chinook salmon were present in both tributary streams in relatively high densities and the Yukon River mainstem in the Minto area, suggesting that both habitats are extensively used there.

The results of the over-winter survey suggest that among small, non-natal streams over wintering is limited to the more southerly parts of the Yukon Basin, and corresponds to the extent of glaciation. The results suggest that the combination of milder climate and stronger groundwater flows from underlying glacial deposits provide conditions suitable for fish during winter. In any area there is likely a relationship between stream size and over-wintering capability, as larger streams are more likely to have adequate base flows in winter. Details on the size, survival and migration timing of yearling salmon are provided in Bradford et al. (2001).

Stream confluence

The impacts of placer mining effluent on mixing zones has been identified as a topic for review (in the 2001/02 YPA review) and these comments describe some recent research on fish habitat at the confluence of small, clear-water tributaries and larger, turbid rivers. The work was conducted in the Dawson region, and concerned small streams that drain directly into the Yukon River mainstem. These areas were all unaffected by recent placer mining.

The objectives of the study were to estimate the density of juvenile chinook salmon in confluence areas, and compare these densities to those along the margins of the Yukon River away from tributary stream confluence; to provide data on the abundance of food organisms in the confluence relative to other areas of the Yukon River; and to describe the general physical conditions in terms of water temperature and clarity.

Physical Conditions

The Yukon River suspended sediment levels ranged from 200 to 500 mg/L during the study, with major inputs from the White River and other tributaries. Water temperature decreased from July to August from 15 to 12 °C. With the exception of rainstorm-induced flood events, suspended sediment levels in the tributary streams were <10 mg/L, and water temperature varied from 4-7 °C. The mixing zones of visibly intermediate turbidities extended 10-20 m downstream from each tributary, in a band 2-3 m in width.

Comment

The results of this survey suggest that the areas of confluence of small streams and the Yukon River are important fish habitat. Chinook salmon juveniles emerge from spawning gravels in their natal streams in mid May, and some move downstream. They appear to enter small creeks in early July, after having grown from 0.3 g to about 1.2 g during their 6-week downstream migration. These results (and others collected in 1999 and 2000, Bradford, DFO; unpublished information) show that creek mouths are the only habitats that are used by salmon in the Dawson region in July and August. In some cases, fish probably leave the stream confluence area and move upstream into the tributary stream. However, in the case of Montana Creek, which is too small and steep to support rearing salmon, the high densities of salmon that were found at the creek mouth suggest that fish may use the confluence of very small streams while in transit to other locales downstream.

The confluence areas likely offer better feeding conditions for young salmon than other areas of the Yukon River mainstem. The drift sampling data show that more organisms are present in the water in the mixing zone than in other areas. However the densities of organisms in the substrate of each area were not different, suggesting that the increase in drifting organisms results from input from the tributary stream to the confluence. It seems also likely that the lower turbidity in the confluence of clear water streams would offer better conditions for visual-based foraging than undiluted Yukon River water.

Assumptions and related issues

Because of the limited extent of the information base that is used to manage fish and their habitat in relation to the effects of placer mining, a number of scientific issues require clarification and understanding. The following exemplify some of those considerations that require attention for the mutual benefit of industries and governments.

Reliance on the chinook salmon as a basis by which to monitor the status of habitat in relation to impacts of placer mining incorporates controlling variables that are impossible to account for. The majority of the life of these fish occurs in the marine environment and therefore outside of the control of factors in the Yukon. This comment is not intended to imply that chinook salmon are unimportant, but to indicate that many factors affect the survival of these fish and accordingly it is not possible to specifically relate e.g. the harvest of populations of adult salmonids to placer mining impacts. Impacts are most likely to be determined on the juveniles.

It has been assumed by some that there is "surplus" habitat in the Yukon and fish populations will not be affected by habitat changes due to mining. But, according to Bradford (DFO; unpublished information) available evidence does not support the notion of surplus habitat. Chinook salmon utilization of available streams under current escapement levels is high, suggesting that habitats are fully utilized. This assertion is supported by stock-recruitment analysis, that shows current escapement targets are biologically based.

The relative lack of emphasis placed on the protection of Arctic grayling cannot be supported based on research findings with respect to their sensitivity to sediment, for they have been determined to be another sediment-sensitive salmonid (see McLeay et al. 1987). Furthermore, this species has fidelity to feeding, spawning, and migration routes (Buzby and Deegan 2000), and loss of such habitats that support these life-cycle requirements would be expected to be significant to the survival of the particular stock. While one may speculate that this would also be so for some other freshwater species of fish, the information base upon which to draw such conclusions is inadequate for the task.

There is also the assumption that "deferred watercourses" (i.e. habitat protection is deferred until mining is completed) will naturally recover from the effects of discharges of sediment, however, there is no information (studies) on the recovery of streams that have previously been "deferred." It would be expected that recovery would be a process that would occur, but the time frame for it would be difficult to predict and would likely span tens or hundreds of years depending upon site-specific circumstances (see below).

Type IV streams are not subject to water quality standards, and can receive mine effluents with very high suspended sediment levels (3,000-15,000 mg/L). In general Type IV streams are headwaters of larger watercourses and it has been generally assumed that the discharge of high levels of sediments into the headwater streams will not impact fish and their habitat further downstream. The premise is related to sediment transport out of the system and the expected downstream "dilution" of these waters. However, Bradford (DFO) comments that effluent discharges into Type IV streams have been shown to reduce, and in some cases eliminate primary and secondary productivity. These upper watershed headwater streams, while not always being occupied by fish, contribute to the life of organisms in downstream locations (such as streams classified as Types I, II, III). These watercourses supply water which, in itself, is an indispensable component of the habitat of fish, but that aside, they provide the basic requirements of the food web (as covered under the habitat provisions of the *Fisheries Act*); requirements that are susceptible to the discharge of sediment. Furthermore, Bradford's research has shown that juvenile fish use the confluence of Type IV streams and large rivers. Hence to accommodate such findings and concerns sediment discharges require regulation. They need to be reduced from the now-permissible 5 mL/L (equivalent to many thousands of mg/L; concentrations that are known to adversely affect fish and their habitat).

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